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EDITORIAL.

FIJI SHOW.

Arrangements are well in hand for the Annual Fiji Show to be held in October next. This year it is hoped that the Agricultural and Horticultural Sections will be more truly representative of the Colony's primary industry. Doubtless the Show suffers from the lack of a permanent home, which necessitates a very rapid preparation of the buildings now used and hurried arrangement of many of the exhibits. Even these difficulties can be largely surmounted by closer co-operation between exhibitors and the officials of the Show. Early entries enable the available space to be planned and allocated to the best advantage.

The Department of Agriculture proposes to take a more active part in the Show this year by staging a departmental exhibit which is being prepared under the direction of a committee of senior officers. It is intended to arrange for illustrated lecturettes on important and interesting aspects of local agricultural pursuits. Members of the department will be glad to render any assistance possible to intending exhibitors.

It is felt that the objects of the Show Association are worthy of wider support by the public of Fiji. There can be no doubt that we are all primarily dependent directly or indirectly upon the success with which agricultural pursuits are carried on. The Show offers an opportunity for bringing together examples of the varied plants and crops grown in the Colony, and is important from the social aspect, offering as it does a meeting place under congenial conditions for all those people actively or passively interested in our productions and industries. The Secretary of the Fiji Show Association welcomes inquiries and will be glad to furnish information regarding both membership and participation in the Show.

AGRICULTURAL CONVENTION.

This function, foreshadowed at the Agricultural Conference held in January last under the Presidency of His Excellency the Governor, will be held during the same week as the Show, and will furnish a welcome opportunity for members of the community to discuss important questions concerning local agriculture. Details have not yet been worked out, but it is proposed to select a few of the more urgent questions of the day for consideration, among which will be the noxious weed problem, the present position and prospects of the dairying industry and copra production. The method of treatment will be by discussion, and each discussion will be opened with a short speech by some local gentleman who is intimately familiar with the subject. In order to give opportunities for speaking to as many people as possible, speakers will be asked to intimate their intention of taking part and the duration of speeches will be limited.

NOXIOUS WEEDS.

The recently issued circular and questionnaire on the subject of noxious weed control in Fiji is printed in this Journal. The response to the request for information from practical agriculturists is most gratifying and that so far collected is of great value. The data received is being abstracted and correlated with a view to publication in a later issue of the Journal. The material will be of value as a basis for extended discussion at the Agricultural Convention, and it is hoped that later it will provide a foundation for a determined campaign directed to the reduction of the serious losses to many agricultural pursuits caused by the prevalence and spread of these undesirable plants.

Information from any persons interested in the subject who have not already furnished replies or who may not have received copies of the circular will be welcomed. Additional copies of the circular and questionnaire will be supplied on application to the Superintendent of Agriculture.

GRASS LAND FARMING.

In this issue, an excerpt from an interesting and informative pamphlet, issued by Imperial Chemical Industries on the modern system of pasture control, is published. The importance to the dairying industry of proper pasture cultivation and control cannot be over-emphasised. Scientific research has clearly shown the benefits to be derived from the utilisation of grass at its period of maximum nutrient value, and has pointed the way to the increased production and profits which may be derived by dairymen who adopt this essentially sound and practicable system of pasture management. At the January Conference the limited supply of concentrates available for the stall feeding of cows in Fiji was bewailed. A method of avoiding the necessity for using any concentrates is available and can be adopted with advantage in such a country as this where growth is so luxuriant as to tempt many of our dairymen to leave their pastures until the grass is long and comparatively indigestible before grazing them. The services of officers of the department are placed at the disposal of dairy farmers who require information regarding the establishment and layout of pastures, manures and implements for grass land cultivation. Literature on the subject may be consulted in the Library at the Suva offices.

AGRICULTURAL STATISTICS.

A committee consisting of the Assistant Colonial Secretary, the Acting Secretary for Native Affairs, the Inspector-General of Constabulary and the Superintendentent of Agriculture (Chairman) was appointed to consider and report upon the method of collecting agricultural statistics. As a result of the committee's recommendations, it has been decided to alter the method of obtaining returns, to call for returns as on 1st July each year and to use a simplified schedule including only the principal crops. Returns under the new system will be called for shortly in respect of the year 1st July, 1929—30th June, 1930.

COPRA.

In his paper on the "Effect of Mould Action on Copra," Mr. Blackie has called attention to a hitherto little discussed aspect of the various factors which contribute to the deterioration and loss of copra. There is a widely held feeling that improved methods of preparing and handling copra are unlikely to be economically sound; that the small, increased return obtained by placing a better quality of product on the market will be more than

counterbalanced by the increased cost of preparation, and that the producers' interests are more likely to be best satisfied by offering for sale an article of low quality which demands a fairly ready sale rather than by attempting to improve their methods in order to secure the small advance of market price likely to accrue.

Copra preparation is an art which must call science to its aid if it is to succeed in meeting the keen competition of other vegetable oil bearing products. Arguments advanced against improved methods of preparation have in many instances been based on false premises. The few shillings extra per ton obtainable for a better quality have been allowed to obscure the possibilities of putting a greater quantity of the better quality on the market from the same amount of raw material by the adoption of improved processes of preparation.

The serious losses of produce occasioned by mould action was discussed at the recent Imperial Mycological Conference, more particularly in their relation to the cacao industry. It is evident to anyone familiar with the copra industry that similar factors exercise a grave influence on the economics of that industry, and it is clear that research is necessary to measure the losses and to evolve means of minimising them.

Mr. Blackie has discussed the problem in a deeply thoughtful manner. His paper affords a useful basis for further work and indicates a measure of the possible increased returns which may attend methods of preparation of copra directed to the reduction of losses by mould action.

MISSION TO TRINIDAD—INTRODUCTION OF LIOTHRIPS URICHI.

PREFACE.

In preparing the attached report on my mission to Trinidad to obtain the thrips *Liothrips urichi*, I have commenced with an introduction, containing first a short history of the pest *Clidemia hirta* in Fiji and the early inquiries which led up to the attempt to control it by biological methods, followed by a brief narrative of the present mission. A few details of the life history of *Liothrips urichi* have next been given and of those factors which tend to limit its numbers and efficiency, several additional enemies of this useful insect having been discovered and now recorded for the first time. Following this the natural control of *Clidemia hirta* is discussed at some length, a number of new facts being recorded which throw fresh light upon the agencies which hold this group of plants in check in their natural habitat, leading to conclusions considerably at variance with those hitherto held.

During the course of this work much assistance has been received from the various officers with whom I was brought in contact. Specimens of the various insects recorded herein have been sent to the Imperial Bureau for identification, but at the time of preparation of this report, such identification has not been received.

HISTORY OF THE PLANT CLIDEMIA HIRTA IN FIJI.

The plant *Clidemia hirta* is a member of the natural order *Melostomaceæ*, and is supposed to have been accidentally introduced into Fiji, with coffee plants from British Guiana, some time prior to 1890. It was first noticed growing along certain wire fences in the Waimanu Valley, near Suva, whence it spread into the adjoining paddocks, especially around stumps and bushes. Soon after this it began to assume the proportions of a major

weed, invading the permanent cultivations and native forests. Its spread into the pastures was particularly serious, as it soon greatly reduced their carrying capacity. There is little doubt that it was the presence of the introduced Mynah bird of India, which, feeding upon the berries and haunting cultivated lands and paddocks, led to the phenomenally rapid spread of the plant. As soon as the danger of the new introduction was realised, Knowles, then Superintendent of Agriculture, took steps to have the plant identified and to ascertain its native habitat.

About 1920 correspondence was opened with Jamaica, British Guiana and Trinidad to find out whether any agencies were known to hold the plant in check in those countries. Dry material and drawings of the flowers were also prepared by the writer and forwarded to Trinidad for comparison with the local species, recorded under the same name.

As a result of the attention thus called to it a number of plants of *Clidemia hirta* were dug up and placed in the old experimental station at St. Clair. Whilst thus under observation Mr. F. W. Urich discovered the thrips, which now bears his name, feeding upon the young foliage. He worked out its life history, recording at the same time certain natural enemies tending to hold its numbers in check. These were three in number, and will be dealt with later, together with certain additional ones discovered during the present mission. At the time that Urich made these discoveries no very great value was placed upon the controlling effect of the thrips, and no further action was taken in the matter until 1927, when Mr. T. H. C. Taylor, who was visiting Trinidad in connection with coconut work, made a "preliminary study of the plant . . . . . with a view to finding some controlling factor, which might be applied to Fiji." (Council Paper, Fiji, No. 14 of 1928.) This officer expressed a favourable opinion as to the value of the thrips and it was decided to investigate the matter further. Through the courtesy of the Principal of the Imperial College of Tropical Agriculture, Colonel Evans, a student (Mr. W. Cook) was detailed to carry out a series of feeding experiments to test whether this insect could be induced to attack any plant of economic importance, which would render it dangerous to introduce it into Fiji. This entomologist's investigations also proving favourable, it was decided to attempt the introduction of the thrips into Fiji and I was instructed to carry out the work. With this object in view I left Suva on 5th September, 1929, travelling *via* Auckland and Panama and arriving at Trinidad on 21st October.

On arrival at Port of Spain, after first calling upon His Excellency the Acting Governor and the Colonial Secretary, I went to the Experimental Station at St. Clair where I called upon the Acting Director of Agriculture, Mr. G. M. Gilbert, who introduced me to the Superintendent of the Botanical Gardens, Mr. O. H. Williams, who subsequently gave me much assistance in my work. Later in the day Mr. F. W. Urich who had made the original discoveries in connection with the thrips called and took me to a place where he was able to show the plant with the thrips at work upon it. Having finished these preliminary matters in town I proceeded to the Imperial College at St. Augustine where it was proposed that I should carry out my work. Here I was very kindly received by Mr. H. A. Ballou, who was acting during the temporary absence of the Principal, Colonel Evans, and a laboratory was placed at my disposal.

VISIT TO BRITISH GUIANA.

As soon as work was commenced it was noticed that there were certain indistinct differences between the Trinidad form of *Clidemia hirta* and that causing so much trouble in Fiji. As the Fijian species was supposed origi-

nally to have come from British Guiana, inquiries were made to see whether the plant was readily obtainable there and the reply being satisfactory, a flying visit was made to Georgetown and a quantity of material obtained from that district.

A thrips similar to the Trinidad species was found to be present in small numbers, but with evidence of being more abundant in the dry season. The general appearance and growth of the plants was more like that to which we are accustomed in Fiji. This may, however, be due to the fact that the heavy wet clay is more akin to the conditions in the latter country than the rocky hills of Trinidad.

COLLECTION AND TRANSPORT OF THE MATERIAL TO FIJI.

Owing to the rocky nature of the soil in those parts of Trinidad where the plant was to be found, considerable difficulty was experienced in obtaining sufficient quantities and establishing them in the tins in reasonable time. Another difficulty was met with in the form of White Fly, which was found on most plants dug up and which in the breeding cages, increased rapidly, causing much loss. Efforts were made, by breeding from adults only, to eliminate the natural enemies of the thrips, but although their numbers were greatly reduced this was not entirely successful, and as with previous importations, careful screening was necessary on arrival.

Seventeen cages, each containing nine tins with growing plants of *Clidemia hirta* were prepared and infected. These were shipped from Trinidad on 8th February, arriving at Colon 12th February, in good condition. At Colon they were railed across to Balboa where they were held in one of the goods sheds until the departure of the "Zealandic" for Suva. This latter was delayed until 23rd February, necessitating ten full days for the plants in the darkness of the shed. This led to considerable destruction of food owing to the numbers of the thrips and the unfavourable growth conditions for the plant. Immediately the ship put to sea these were carefully gone over, cleaned up and many hundreds of thrips and pupæ renewed. The latter were placed into cool storage to check development, a method which had been tested whilst in Trinidad and which proved very successful. In addition to the insects in the breeding cages a large number of young shoots of *Clidemia* with eggs upon them had been collected just prior to sailing; these were placed in water. After much search two strong plants of what appeared to be the same species were found at Ancon. Although differing considerably in general appearance from the Trinidad or Suva form of *Clidemia hirta* it was found that the thrips took quite kindly to these also.

As a result of these combined methods an immense number eggs, nymphs, pupæ and adults of the thrips reached Fiji in good condition. To what extent this introduction will prove successful remains to be seen.

DISTRIBUTION IN FIJI.

In order to prevent the possibility of introducing any undesirable insects with the thrips, adults only were removed from the imported material, by hand, and placed upon leaves from local plants. These leaves were then laid upon growing plants, which were kept covered by a screen. In this way 2,500 adults were released by the 15th March, and a further 900 on the the 17th, when it was observed that those liberated on the 15th had commenced to oviposit upon the Fijian plants.

LIOTHRIPS URICHI, KARNY, AND ITS HOST, CLIDEMIA HIRTA.

The life history of *Liothrips urichi*, Karny, has been worked out, first by Urich and later by Taylor and Cook. The last named gave a very care-

ful description of the various stages, so that no further work on these was felt necessary, the details only being checked over. It was noticed, however, that the description of the egg, as smooth, was incorrect, it being covered with minute hexagonal pustules, which seem to have escaped observation. These pustules were absent from what is presumably the micropilar end.

The following are a few brief notes on the different stages:—

Eggs.—These are generally laid on the under surface of the terminal pair of leaves, or on the adjoining stem; occasionally, however, they were found near the base of the next older pair.

Nymphs.—These feed on the more succulent portions of the plant, either stem or leaves, and sometimes on the flower buds. In this latter case they cause the bud to drop off. They are crimson in colour with two black scutiform plates on the prothorax and two black oblong plates on the eighth segment and the tube. There are only two nymphal stages, both similarly coloured.

Prepupa —This is also crimson, but those portions which are black in the nymph, are transparent in this stage. It is easily distinguished from the pupa by the absence of wing buds and the free antennæ.

Pupa.—This is also red, but has the antennæ fixed to the sides of the head and has well developed wing buds. Both pupa and prepupa are capable of movement but take no nourishment and are placed on the under-surface of a leaf, generally congregated at the bases. These wilt, dry up and fall to the ground.

Adults.—The adults are shining black with well developed wings. They are to be found in the same situations and associating with the nymphs and pupæ.

NATURE OF DAMAGE INFLICTED UPON THE PLANT.

The insects feed, either as nymphs or adults, by sucking the juices of the plant, which develops a brown spot surrounded by a pale area at the point of attack. The adults also often attack the veins of the young leaves causing them to contract and curl over, so that the head of the attacked plant is generally distorted and has a washed-out appearance. As the terminal foliage is destroyed the nymphs move down the stems, which die back. In the case of young plants this die-back is apt to extend to the roots, which, however, are not injured and normally the plant throws up new growth unless other conditions are unfavourable. The effect of the destruction of the terminals is to give the plant a stunted appearance in those areas where the thrips is abundant, as compared to where it is absent. In the wet season, however, the attacks are less severe and the plant makes rapid growth, producing quantities of flower, and it seems probable that were it not for the destruction of these by agencies, to be mentioned further on, the effect of the thrips in preventing the spread of the plant would not be very great.

In the breeding cages it was observed that, as the terminal shoots died back, the adults did not oviposit upon older leaves, but left the plant, flying freely and crowding upon the calico sides of the cages. It was also noticed that they showed a greater tendency to oviposit in the sunshine than when the cages stood in much shade. This is also the case in the field.

NATURAL ENEMIES OF LIOTHRIPS URICHI, IN TRINIDAD.

When, in 1922, Urich discovered *Liothrips urichi*, he also found that it had several natural enemies, being attacked by a Chalcid, *Tetrastichus thriphonus* and two predators, both undetermined, one a Reduviid and the other a Cecidomyid. More recent workers do not seem to have found these checks

on the number of the thrips much in evidence. Taylor states: "Urich has bred a Chalcid parasite, *Tetrastichus thripophonus*, Wst, from the prepupæ of *Liothrips urichi*. No other natural enemies are known. We did not find this parasite, and believe it to be uncommon as a rule."

Cook states: "*Liothrips urichi* has very few natural enemies, a small hymenopterous parasite and two predators, a Cecidomyid fly larva and a small brown Reduviid bug, all discovered by Mr. Urich, are the only ones known." He goes on to say that he only found one of these, the Cecidomyid, and that this: "was only observed on comparatively few occasions."

In the course of the very large amount of material examined on this Mission it was found that natural enemies were more in evidence than earlier workers had believed, several additional species being met with. The most important was undoubtedly the Cecidomyid, which was often very abundant, there being sometimes as many as three larvæ on one leaf. In these cases they quickly destroyed all the thrips present, attacking these in the nymphal stage and it was concluded that, whilst perhaps not actually specific, this insect was a special enemy of the thrips and that it probably destroyed 30 per cent. to 40 per cent.

The Reduviid was found as a somewhat scarce predator and may be a general feeder. It was present in the breeding cages, where the eggs were discovered. These are a pinkish-yellow, shaped like a soda water bottle, with a white fringe around the operculum and were found two side by side on the surface of the main terminal of the plant.

The Chalcid was met with only on one occasion and is evidently not abundant upon this insect, but there is reason to suppose that it may have other hosts.

In addition to these already known enemies of the thrips several new ones were met with. The most important of these was a predatory mite, shown in Fig. 9.* It is crimson in colour and hard to find as an adult as it had a habit of jumping from a leaf when this was touched. It was observed to attack both nymphs and adults. Being exceedingly small it easily escapes observation and this makes it difficult to estimate the extent of its attack.

A small black bug, rather larger than an adult thrips, which it decidedly resembles, was observed to suck the eggs of the thrips and occasionally destroy the pupæ. This species was only discovered towards the end of the investigation and the extent of its influence is unknown, but one bug is capable of destroying a very large number of the thrips.

In addition to the above which may be special enemies of the thrips, several general predators were observed feeding upon this insect. One of these, a small jumping spider, was not uncommon, but its effect would be hard to estimate. Another was the green larva of a Syrphis fly, which could destroy as many as seven nymphs in a night. This fly was not reared to maturity and was only met with on about three occasions. Ladybirds were also bred out of infected material and may destroy a certain number, but were more likely predatory upon scale insects.

From the above it will be seen that *Liothrips* has in Trinidad a considerable number of natural enemies, the elimination of which should greatly increase its efficiency in Fiji. There are, however, in the latter country several species of thrips, which are all rare insects, and may have special enemies holding them in check. In this case it is possible that some of these may turn their attention to the new introduction and thus offset the effect of such screening out. This, however, can be tested only by time.

* Figures not reproduced.

Fungus destroys a certain number of both nymphs and adults and on one stem of *Clidemia* gathered in the wet Aripo Valley five out of nine had been destroyed by this agency. This fungus caused considerable losses in my breeding cages and is probably allied to *Sporotrichum globuliferum* which which often proves very fatal to the cacao thrips.

CLIMATIC CONDITIONS DETRIMENTAL TO THE THRIPS.

Liothrips urichi is reported as being more abundant in the dry season than in the wet. The writer was in Trinidad mostly in the wet season and his experience tends to bear this out. It was observed that whilst the thrips was to be found all over the island it was very scarce at this season of the year in the wet Mora Forest and along the Cumuto Road, in the Central Ranges whilst it was far less common in the wet Arima Forest than in some other parts, considerable clumps of the plant being free. In such localities the plant grew into tall bushes 6 or 8 feet high, but was no more abundant than in other places where the thrips led to a stunted growth. It was also observed, both in the laboratory and in the field that the insect did not like dense shade, and did not oviposit freely in such situations.

Those districts in Fiji in which *Clidemia* hirta has become such a pest are considerably wetter even than the Mora Forest, and it remains to be seen whether there are favourable factors which will compensate for this somewhat unsuitable climatic environment.

THE NATURAL CONTROL OF CLIDEMIA HIRTA AND ITS ALLIES IN TRINIDAD AND FIJI.

Three and a half months were spent in collecting and preparing the material which was to be sent to Fiji and, whilst carrying out this work, it was decided to investigate further the causes which inhibited the spread of *Clidemia hirta* in Trinidad, as it was felt that there were other and more powerful agencies present than the thrips. Further it was observed that the thrips did not thrive in certain wet districts and this intolerance of wet conditions suggested a possibility that the insect might not thrive in the far wetter climate of Fiji. In view of the seriousness of the weed in Fiji it was felt that every effort should be made to ascertain whether any other agencies were present, checking the spread of the plant in Trinidad. The resulting investigations were attended with a considerable measure of success and a number of discoveries made regarding the biological control, not only of *hirta*, but of all the members of the genus, and resulted in conclusions greatly at variance with those previously held.

Habitat.—The *Melostomaceæ*, to which order the genus *Clidemia* belongs, are a dominant group in the West Indies, being rich in both numbers and species. They occur as small shrubs, similar to *Clidemia hirta*, up to bushy trees 12 or 15 feet in height. They require a good deal of moisture and in Trinidad form a considerable portion of the secondary growth about the foothills.

Clidemia is represented by a number of species, the commonest being, *pustulata, hirta, dentata, rubra* and *neglecta.* All these have similar habits, being found along the forest traces and in the partial shade of secondary growth and in clearing in the jungles. None of the genus was ever seen in the dense masses characteristic of *C. hirta* in Fiji, but both *pustulata* and *hirta* were abundant in places, the former being the only member of the group to occur anywhere in such numbers as to constitute a weed. This it did in two or three places, notably in a clearing in the poor land near the railway at Arima and again near Sangre Grande, in what is known as the Long Stretch, where it formed a considerable portion of the growth along the edge of the road.

Competition.—It has been suggested that competition of other plants is an important check upon the spread of this other and weeds and Cook gave a list of the plant association in which *hirta* was found. There is no doubt that competition is a factor, but the present investigations indicate that this competition takes its most intensive form in the effort of the plants to produce sufficient seeds to overcome the losses, which will be indicated later, and thus to reach suitable habitats as they become exposed. Once the seedling is established in its new haunt it seems capable of competing with the secondary growth, and produces seeds until such time as a new competition arises, caused by the growth of taller vegetation, which nursed under the shelter of the secondary, sun loving plants, eventually shades them out.

Ecology.—It has also been suggested that ecological factors were the paramount ones in deciding the relative abundance of the various species in any plant association. The present investigations, however, indicate that it is the biological factors which control the numbers, although of course the ecological factors will decide whether a plant shall be actually present in, or totally absent from any locality to which its seeds have access. It seems also probable that where the ecological conditions are only partially favourable that the plant will be replaced by other more suited species, rather than that it will continue to exist in small numbers only.

In any case, when a plant has invaded a new country to the extent to become a major noxious weed, it shows that the ecological conditions are favourable and, as in most cases, it would be impossible to change these permanently over any considerable area, it is only from biological methods that relief can be hoped.

BIOLOGICAL AGENCIES.

In approaching the matter from a biological standpoint three main lines of study suggest themselves:—

1. Those factors which assist the seeds to occupy quickly any suitable positions that become vacant.
2. Those factors which lead to the destruction of the seeds either before or after production.
3. Those factors which weaken the plant sufficiently to reduce seed production.

To deal first with those agencies which assist the spread of the plant in Fiji. The fruits of the various species of *Clidemia* are small purple berries, much relished by certain birds. Jepson has shown that the small seeds pass through the alimentary canal undigested and are thus distributed. There is little doubt that it was the presence of the Indian Mynah bird which, haunting cultivated lands and pastures, led to the very rapid spread of the weed in Fiji. It is of interest that the same bird is also considered the main agency in the spread of another weed, *Lantana* in that country. Other birds also assisted in distributing the new plant, particularly doves and pigeons and these are probably the chief agencies in the bush and forest country.

AGENCIES WHICH CHECK THE SPREAD OF THE PLANT IN FIJI.

Ecologically Fiji proved highly favourable to the plant, which rapidly occupied large areas in the wetter portions of the group. There have, however, been a few reports of the plant dying out from areas where it formerly flourished. The first of these was in 1919 and was investigated by the writer. The cause of the death of the weed proved to be connected with the attacks on the roots by a nematode of the *Heterodera* group. either

directly or indirectly by allowing the entrance of parasitic fungi. The disease was found to be confined to certain of the poorest classes of land, and whilst one or two other reports of a similar nature and due to the same agencies have come in, it has always been on the same poor type of soil and of little economic value in the control of the plant.

AGENCIES WHICH ASSIST IN SPREADING THE PLANT IN TRINIDAD.

In Trinidad doves are numerous and I am informed that the berries of these plants are often to be found amongst their stomach contents. These are forest and tree loving birds and whilst there are doubtless other species which feed upon this class of berry, there does not seem to be any with quite the same habits as the Indian Mynah to spread the plant over pastures and cultivated lands.

AGENCIES WHICH ASSIST IN PREVENTING THE SPREAD OF THE PLANT IN TRINIDAD.

In studying those causes which prevented this plant spreading unduly, it was frequently noticed towards the end of the wet season that there were numerous patches of bare soil along the forest traces, frequently damp and moss clad, ideal as seed beds for *Clidemia hirta* and its allies, which were unoccupied, and which would, in Fiji, produce quantities of young seedlings of the plant. Their absence in Trinidad did not suggest that the position was unsuitable, but rather that the seeds were not there to occupy the favourable situation thus exposed. In support of this conclusion Taylor states in his report on his investigations into the natural control of the plant in Trinidad: "We were impressed with the scarcity of fruit on *Clidemia* all over Trinidad," suggesting as a reason that "the thrips certainly plays an appreciable part in producing this state of things." Whilst agreeing as to this scarcity of fruit I was not satisfied that the thrips was the principal factor in bringing it about for the following reasons:—

1. The thrips was absent from all other species of *Clidemia*, yet the same failure to produce seeds was equally noticeable in these.
2. The thrips was absent or almost absent in certain wet districts and under the shade of cacao at places, yet although the plant grew luxuriantly it showed no signs of spreading unduly and there was still the same paucity of berries.

It was felt that the key to the position lay in the absence of seeds and investigation of the causes showed, that from the moment that the buds are formed until they reach maturity they are subject to the attacks of a series of insect enemies, which exert a pressure so severe as to result in the destruction of probably over 95 per cent. The conclusion was arrived at that it was seed destruction that was preventing the undue spread, not only of this plant, but also of all other species of the genus.

These controlling agencies were found to belong to a number of different species and even to different orders; some general, some specific and other apparently generic in their feeding habits.

INSECTS WHICH DESTROY THE SEEDS OF CLIDEMIA HIRTA, IN TRINIDAD.

Of those insects which destroy the seeds of *Clidemia hirta* the most abundant is probably a small Chalcid, which forms hard galls within the berries. At the time of my arrival it was present in probably 95 per cent. of all berries which reached full growth, but as the dry season advanced it grew scarcer, possibly due to an increasing wave of parasitic pressure and several localities were found from which it seemed to be absent. The effects

of its attacks varied with the size of the berry and the number of the insects present. If the attack did not take place until the berry was nearly full grown, and only one Chalcid was present, this gall was generally in the central pith and little damage seemed to result. If, however, the attack took place earlier it generally resulted in the premature fall of the berry, whilst if, as was usually the case, a number of galls were present in the same capsule, there took place a hardening of the tissues together with premature ripening, and loss of healthy seeds. Such berries were generally enlarged and very distorted. This Chalcid (Fig. 11) was subject to the attacks of a second Chalcid (Fig. 10) which was very abundant whilst a Braconid also occurred. This valuable species seems to be absolutely confined to *C. hirta*.

Lepidoptera.—Next to the Chalcid the most numerous of the seed destroying insects was a very small pink caterpillar. As a destroyer of seeds this was possibly the most important single agency. It was found commonly in the seed capsules of both *hirta* and *pustulata*, probably also attacking the other species of the genus. It showed a preference for the younger berries, but also attacked older and even ripe ones, causing them to fall prematurely, with total destruction of their contents. When fully fed the larva leaves the berry and spins a tough silken cocoon at the junction of two veins of a leaf or in a shallow in the stem, weaving a few hairs from the plant into its shelter.

The most remarkable thing about this insect is, however, that there is on *C. pustulata* a moth which forms galls in the stem, but which is never found in *C. hirta*. This moth is morphologically indistinguishable from this insect, but does not leave the shelter of the gall to pupate, whilst the caterpillar seems to be more variable. It seems probable that it is biologically distinct as its incidence did not always correspond with that of the seed-eating form. (See Figs. 17 and 23, resting position, also Fig. 22 larva.) Almost as abundant was a small greenish white caterpillar, resulting in the grey moth shown in Fig. 16. It attacked the berries at stages, causing them to fall off prematurely resulting in their total loss. This or a closely allied species was found to be the most abundant of the seed destroying agencies in the patch of *Clidemia* examined in British Guiana. Whilst what may be the same species was observed, but not bred out, feeding beneath the flower buds of *C. pustulata*, causing them to fall without opening.

In Fig. 15 is shown a pretty pinkish moth which was bred from an external feeding green larva and also from internal white ones. Time did not permit of checking this over and it seems probable that a mistake has occurred. The larva in the laboratory spun its cocoon as a rule between two berries. It was found (unless some confusion of the species has occurred) to be parasitised by a brown Braconid, shown in Fig. 12, which pupated within the berry. It is not always easy to be certain to which larva these internal species belong, as if removed from their surroundings they will seldom return and the breeding of the moth from the green external feeder suggests that an error has been made, although is it possible that the species is occasionally external in its habits, and the effect of the light is to bring out the green colour.

External Feeding Lepidoptera.—Siderus leucophagus.—Fig. 19 top and underside; Fig. 18 larva. The larva of this beautiful butterfly was found feeding upon the flowers and berries of *C. hirta*. The butterfly was never seen, but the larvæ were found from time to time. They match their surroundings most perfectly and were very difficult to discover. Like all the group it suffers much from the attacks of enemies and in the laboratory a nematode (Mermis sp.) was bred out. Its attacks on the berries resulted

in their total destruction, as they hollowed the interior completely out. Although rare in Trinidad, in another country, relieved of its natural enemies it might become of considerable value and it has the advantage of belonging to a group usually highly specialised in regard to feeding habits.

Fig. 13 is another external feeder. The larva is generally pink speckled with black, but is somewhat variable. As a rule it spins the flowers together and feeds upon the buds and young berries. One specimen was met with right inside a berry. The moth was first bred out by Urich. It is a most remarkable insect, with immensely long labial palpi, which are banded black and white, and are curved back over its head. The legs are also decorated in the same striking contrasts.

Another external feeder is shown in Fig. 21 (adult) whilst the larva is shown in Fig. 20. It was found in wet Arima reserve. The larva possesses very attenuated thoracic segments, and feeds by making a small hole in the side of a berry and completely clearing out the contents. It also constructs a funnel of silk, within which it lives and pupates. The adult moth is very beautifully coloured in brown and a metallic shade of silvery white.

Leaf Feeding Insects.—A number of insects were found to feed upon the foliage of the plant, but none would be safe to introduce into another country. In the field the most frequently seen of these leaf insects was the Pyralid moth shown in Fig. 14. The larva of this species is a leaf roller and was found to be not uncommon.

A second species made a hard case out of silk, recalling the cocoon of the European Puss Moths. This larva was brown with a yellow stripe on each segment and lived within the case, leaving an opening at each end to allow it to come out to feed. When full fed it closed the two ends forming a barrel shaped cocoon and pupated within.

Another lepidopterous insect was a leaf miner. This was not bred out and was, in Trinidad, of no importance.

A few specimens of a curious phytophagus beetle were bred in the cages and subsequently met with in the field.

Three homoptera proved troublesome in the cages. The worst of these was a species of Aleyrodes (white fly) which not only destroyed the foliage, but attracted ants. Next, in point of numbers, was a mealy bug, which became very bad in one or two of the cages, whilst the last of this group, also in the cages, was a yellow scale, of the Lecanium type.

Fungus Diseases.—In one or two of the wetter valley a fungus was observed on the foliage. This was identified as an Irenia sp., a group described as mildly parasitic.

INCIDENCE OF THE VARIOUS CONTROLLING FACTORS.

It was observed that the incidence of the various controlling factors varied greatly. Thus, in several of the wetter districts, such as the Mora Forest, the Arima Reserve and some portions of the Central Ranges, the thrips was practically absent. In these localities the weed grew into fine bushes six and even eight feet high. In the Central Range locality the gall Chalcid was also missing and control was almost entirely by the internal and external seed caterpillars, principally by the pink one. In a batch of berries collected in the Maracas Valley the white larva producing the moth shown in Fig. 16 was the most abundant species. It was also observed that as the dry season advanced there was a considerable change in the insects attacking the plant.

EFFECT OF INSECT ATTACKS UPON SEED PRODUCTION IN CLIDEMIA HIRTA.

A large number of berries of *Clidemia hirta* collected in different localities were opened and an examination of the contents made. A typical specimen will be detailed here, and it is proposed to tabulate a few others as an appendix.

The branch in question was taken from a fine plant, some six feet high, growing in the wet Arima Forest. It was one of a group that were free from attack by thrips, but although evidently long established there were no young plants found and the group was not apparently spreading with any rapidity. On this branch there were three fruiting bunches, the oldest consisting of only two berries, about half grown and both completely eaten out by lepidopterous larvæ. There was no doubt that the others on this bunch had all fallen prematurely from insect agency.

The next younger bunch consisted of eleven berries, six being green and five brown. Of the green ones four contained caterpillars and two were still sound, whilst all the brown ones had been eaten out by caterpillars. In the youngest bunch there was an unopened bud and one flower, both normal. There was one sound berry, six brown buds, five having been hollowed out by caterpillars and five green berries also containing caterpillars.

It will thus be seen that exclusive of the buds and flower, there were twenty berries, of which only three were still sound and these would still have to run the gauntlet of further caterpillar attacks and as they reached half size, become liable to the attacks of Chalcids. It will thus be realised how heavy is the pressure exercised by these seed-destroying agencies and the conclusion was forced upon me that it was considerably over 95 per cent. of the possible production that was thus destroyed perhaps over 99 per cent. In British Guiana it was noticed that the bud and flower destroyers were not so much in evidence and that the plants set far more berries. The pink caterpillars was not found, but is doubtless present in places. As a consequence there were far more berries, but these were nearly all attacked by the greenish-white larva, with what ultimate effect I was, however, unable to ascertain. The destruction must, however, be very severe.

CONCLUSION.

In Trinidad the plant *Clidemia hirta* is subject to a considerable number of insect enemies, which prevent its undue spread. The most important of these seem to be those species which destroy the flowers and seeds. These collectively seem to destroy over 95 per cent. of the possible seed production. This destruction is common to all the members of the genus, but the casual agencies are not always the same. *C. hirta* alone seems to be attacked by the gall seed Chalcid and, with the single exception of the *C. dentata* record, is the only host of the thrips. Whether this is offset by an ability to produce a greater quantity of seed than other species of the genus I would not like to say, but it did seem that *hirta* and *pustulata* were more continuously in flower than the others.

It was found that the value of the thrips as a control was much reduced by its own natural enemies and every effort was made to reduce as far as possible the numbers of such gaining access to the cages. If success is attained in screening these out the efficiency of the insect should be greatly increased; but, in Trinidad, *Liothrips* was particularly susceptible to wet conditions and as the areas of Fiji in which *Clidemia hirta* is found are, as a rule, very much wetter than Trinidad, it remains to be seen whether any success that has been met with in screening out natural enemies will be

sufficient to offset this probable unfavourable environmental condition. Should, however, it be found that the effect of the thrips in Fiji is not so great as could be desired the insects discovered in the present Mission and discussed in this report offer encouraging prospects of eventually being able to bring this troublesome weed under close biological control.

In the Appendix will be found details of—

(1) Seed Examination.

(2) Temperature Experiments.

(3) Technique.

THANKS.

In conclusion I would like to express my sincere thanks to Col. G. Evans, Director of the Imperial College, who placed a laboratory at my disposal and extended much hospitality; to Professor H. A. Ballou, for kind assistance and advice; to Mr. S. M. Gilbert, Acting Director of Agriculture, who also rendered every assistance in his power.

I am particularly indebted to Messrs. F. W. Urich and R. O. William, who placed their great knowledge of the local entomology and botany at my disposal, besides assisting in many other ways. I have also to thank Mr. R. Dick for naming specimens.

My sincere thanks are due to Mr. B. Martyn, Mycologist, British Guiana, who assisted in the very wet and dirty task of obtaining the plants from that country, and to the Government Entomologist, Mr. L. D. Cleare, for kind hospitality.

I am also greatly indebted to His Excellency Col. Burgess, Governor of the Canal Zone, who instructed that my cages should be railed from Colon to Balboa free of cost to this country.

Finally to Dr. J. Zetek of the Department of Agriculture, stationed at Panama Canal Zone for kind hospitality and assistance, as also to Captain Jones of Andrews & Co., and Mr. W. Smith of Elders & Fyffe, for assistance in shipping my cages.

H. W. SIMMONDS,
Government Entomologist.

APPENDIX A.

TECHNIQUE FOR HANDLING LIOTHRIPS URICHI.

Previous workers have removed adult thrips by means of a blunt pointed needle, a tedious and slow method, resulting in the injury of a number of the insects. Effort was therefore made to evolve a more satisfactory system and the following was found to work well:—

Infected material was collected in the field and carefully gone over with the lens, any adults present being removed by means of the needle. The leaves were then roughly sorted into two lots; one, in which pupæ predominated, and the other consisting of nymphs. The former was then allowed to dry off for about 36 hours, when it was placed into a closed tin, interlaid with portion of fresh leaves and left for a night. The nymphs soon left the dry material for the fresh, whilst the pupæ remained behind, so that a pure culture was obtained of pupæ on the one hand, on the dry leaves and of nymphs on the fresh. The pupæ were then placed into a box until the commenced to emerge, when a few fragments of leaves that had been carefully examined with the lens for undesirables were introduced and kept closed until next day. It was then found that the newly hatched adults would have collected on the fresh leaves, and in this way could be handled in large numbers without loss.

When a fair number of pupæ had collected amongst the nymphs these were again dried off and the pupæ separated from the remaining nymphs.

By using mason jars or tins food could be kept sufficiently fresh for a number of days. It was, however, found necessary to open up the jars each day, otherwise sufficient carbon-di-oxide was given off to kill all life present.

TEMPERATURE EXPERIMENTS.

In order to test the value of cooling to assist in the transport of any material that may subsequently be required, one or two temperature experiments were carried out:—

1. A set of berries, numbering 96, were placed in a cool chamber at a temperature of 53° Fahr., remaining there ten days. When removed Chalcids commenced to emerge at once and continued to do so for 18 days. From this it seems that the effect of this temperature is only slightly to delay development, regardless of the stage in which the insect is at the time placed in the cooler. In addition, four moths emerged on the 18th and 20th days. It seemed to show that these insects could only stand chilling when in one stage, possibly egg or possibly pupal, followed by delayed development.

2. A second box containing fully developed nymphs and pupæ of *Liothrips urichi*, was subjected to similar treatment for twenty-one days, all surviving.

APPENDIX C.

RECORDS OF SEED EXAMINATIONS IN CLIDEMIA HIRTA.

In addition to the records of seed destruction given in the text a large number of berries were cut open and a record was kept of a few of the more interesting of these, some of which are detailed below:—

1. A set of twelve berries, almost ripe, were collected from the plant and opened up, when it was found that all had been attacked by insects, six being caterpillars, five Chalcids and one by both.
2. Four berries from under the plant in the Mora Forest were found to contain caterpillars in three and the fourth had one of the only two thrips met in that wet area.
3. Twenty ripe berries collected under bushes in the Northern Ranges consisted of five sound ones, seven containing Chalcids, five of which were quite destroyed and seven totally destroyed by caterpillars, whilst two had dropped from some unknown agency.
4. Twelve seeds picked up under bushes in the Northern Ranges had all been destroyed by caterpillars and Chalcids in equal porportions.
5. Six buds found under the same bushes had all been attacked by insects.
6. Thirteen buds and young berries found under bushes at Arima had, in eleven cases, been eaten out by caterpillars and one had an external wound.
7. A large batch of full grown berries gathered at Maracas were about 95 per cent. attacked by Chalcids, with caterpillars also present.
8. Forty-three berries from under plants at St. Johns consisted of 23 destroyed as recently set buds, probably all the work of caterpillars, eleven eaten out by the same agencies, three contained both caterpillars and Chalcids and five contained Chalcids only. Of the balance four were big berries totally destroyed by external feeders and five contained Chalcids or caterpillars, but had not been so severely damaged and might mature a few less seeds. There was not a sound berry in the whole lot.

MARKETING OF FIJI FRUIT IN NEW ZEALAND.

By James Kermack, Assistant Superintendent of Agriculture and Inspector of Produce.

As directed by His Excellency the Governor, I proceeded to Auckland, New Zealand, by the s.s. "Tofua," on 13th February, for the purpose of observing conditions under which Fijian fruit is carried, discharged, and marketed in New Zealand, and of investigating market conditions in regard to bananas and other produce. After careful observations, which were continued over a period of approximately three weeks, of the various operations relative to

the transport and ultimate distribution to retail merchants of banana consignments, which was the primary object of my mission, and from investigations I made regarding possibilities of markets in New Zealand for a much larger export of produce from the Colony I submit the following information:—

TRANSPORT OF BANANAS TO AUCKLAND.

2. The steamer on which I travelled carried 6,160 cases of bananas put on board in four holds at Suva on the 16th and 17th February, and consigned to the undermentioned Agents and fruit buyers in Auckland:—

A. B. Donald, Ltd.,
Turners and Growers, Ltd.,
Radleys, Ltd.

The fruit, the greater part of which had been harvested at least four days prior to shipment, was on arrival at the wharf at Suva found to be in an unsatisfactory condition. A considerable percentage was overfull and commencing to ripen, whilst a proportion was immature and diseased and although several shippers endeavoured to improve matters by repacking, the danger of the cargo reaching New Zealand in a poor marketable condition was only too obvious. Loading operations left a great deal to be desired in respect of proper handling and I am of opinion that a discontinuance by the Steamship Company of the present "rope sling" system and by substituting "trays," the risk of cases being damaged and consequently fruit bruised by crushing, would be considerably lessened. Every care was, however, taken by the ship's officials in the stowing and dunnaging of the cases and as there was ample room in the holds for a very much larger shipment, ventilation was good and gas from ripening fruit was readily expelled by a fan system which operated from the time loading operations commenced and throughout the voyage to Auckland. I visited the holds of the vessel each day during the period of transport and found that whilst for the first two days there was little or no appreciable change in the appearance of the fruit, a general ripening in many lines commenced on the third day. I attribute the early general ripening solely to the unsatisfactory condition of the fruit at the time it was put on board. Ideal weather conditions for transport did not necessitate the steamer holds being closed during any stage of the voyage and temperatures were even and comparatively cool from the time the vessel left Suva until Auckland was reached.

DISCHARGE OF CARGO AT AUCKLAND.

3. I observed very closely unloading operations which commenced soon after the vessel was tied up alongside the wharf at Auckland. A considerable amount of care was exercised in discharging the cargo on to the wharf on "trays" but I was by no means favourably impressed with the manner in which it was handled by wharf labourers from the ship's side to Customs sheds, cases being frequently lifted from hand trolleys by which means they are transported and literally thrown one on top of another in different piles. I complained on several occasions to the Fruit Inspector who was on duty about the rough treatment the fruit was subjected to and was informed by that official that any interference on his or the Shipping Company's part would probably result in a general strike of wharf labourers, all of whom are associated with strong Unions.

INSPECTION OF FRUIT IN CUSTOMS SHEDS.

4. As I had anticipated, a large proportion of the shipment was found to be in bad condition and shipper's agents, who I learned make as a rule a cursory examination only of the fruit in Customs sheds, experienced on

this occasion great difficulty in selecting from the different lines the quantity of cases of what they considered to be sound fruit ordered by clients for immediate delivery. No systematic inspection was made by the Government Fruit Inspector and approximately 50 per cent. of the cargo was distributed from Customs sheds immediately after shippers' agents had made their Survey. I inquired of the Fruit Inspector the source of information he supplied periodically to the Department of Agriculture, Suva, in regard to the condition of shipments arriving in Auckland from Fiji throughout the year, and he reluctantly had to admit that it was supplied to him by an official of one of the shippers' agents. This admission did not come altogether as a surprise to me after I had been in the Customs sheds but a short time. I do not suggest that the information submitted by the Fruit Inspector is unreliable but his method of procuring it is, in my opinion, irregular and may lead, if it is continued, to the Government of Fiji on occasions taking undue drastic action against shippers whose fruit may possibly have been adversely reported on by an agent's employee in error during the hurried period of distribution in the Customs sheds. The position, however, in regard to fruit inspection in Auckland at present would appear to me to be a difficult one as the Inspector is expected by Government to do the work without any assistance whatsoever. To make a thorough inspection of each line of fruit in the short space of time available prior to distribution, a fairly large staff of competent inspectors would, in my opinion, be necessary.

REPACKING OF FRUIT IN AGENTS' SHEDS.

5. I have already stated that approximately 50 per cent. of the cargo was distributed without proper examination. The remaining 50 per cent. was trucked to the sheds of the different agents where cases were emptied, fruit graded, repacked and sold either by auction or by private sale. I followed closely each operation and was favourably impressed with the careful and expeditious manner in which the fruit was handled. Considering the speed and accuracy with which the culling and grading was carried on it was perfectly obvious to me that a number of specially trained employees are on hand at all times to do this class of work. This would mean that repacking of indifferent fruit has frequently to be resorted to. Here I had also an opportunity of arriving at an estimate of the condition of the shipment. On the assumption that a high proportion of the 50 per cent. distributed without inspection was in a similar condition to the proportion repacked and from my observations in the Customs sheds it may reasonably be inferred that the shipment was the worst since the new Banana Regulations came into force in Fiji in September, 1928. The following statement compiled from notes I made in course of my observations in repacking sheds compares favourably with information I was able to procure from shippers' agents and therefore may be accepted as being correct:—

Total shipment		6,160 cases
Sold without examination	3,023 cases	
Examined and found to be in the following condition—		
Green	1,558 ,,	
Ripe and soft	747 ,,	
Over-ripe, immature and diseased ..	832 ,,	
		6,160 ,,

MARKETING IN CUSTOMS SHEDS AND IN AGENTS' PREMISES.

6. The maximum price governed more or less by supply and demand is arranged by mutual agreement between shippers' agents when they have

ascertained the extent of the shipment and after they have roughly estimated the condition of the fruit. I was not able to find out for what price unexamined fruit sold, but I had some evidence that about 27/6, which I was informed was the maximum on this occasion, was obtained. In the agents' auction rooms prices for repacked fruit ranged from 12/6 to 27/6 according to condition and averaged, as near as I could estimate at times when I attended auctions, 20/- per case. I was satisfied that sales of repacked fruit in agent's premises by auction were conducted in a perfectly straightforward manner and I have no reason to doubt that other sales made by private bargain in Customs sheds and elsewhere were similarly conducted.

VISITS TO RETAIL STORES.

7. Periodically during the first week of my stay in Auckland I visited the principal retail stores in and around the city and from observations I made merchants appeared to have little or no difficulty in disposing of bananas at prices ranging from 4d. to 6d. per lb. It would be difficult to estimate the return to the retailer as occasionally the smaller and poorer fruit I observed was offered for sale by quantity at so much per dozen but I was satisfied that sales by weight of repacked fruit from agents' sheds must have been profitable. The net weight of a case of sound bananas is approximately 80 lb and as the estimated cost to the retailers on this occasion was 20/- per case, a gross profit from sales at an average price to the consumer of 5d. per lb would be 13/4 per case. In considering this apparent high return it must, however, be borne in mind that the retail merchants run considerable risk in stocking ripe bananas during the warm season and are liable to lose through the fruit going bad if there is not an immediate demand. I questioned several of the leading storekeepers regarding banana sales, and all were of opinion that if the fruit were available and could be imported and sold to retail merchants at a reasonable price a very large business would result. In this I quite agree as frequently I overheard remarks of intending purchasers who hesitated to buy on account of high prices asked.

VISIT TO WELLINGTON.

8. After I had studied, for over a week, the situation in Auckland I proceeded to Wellington where I spent four days. Market conditions there, in respect of prices, I found on inquiry to be very similar to those which obtained in Auckland. Unfortunately I had no opportunity of seeing any bananas landed or auctioned in Wellington, but I was informed that only small consignments reach that port principally from Rarotonga and Samoa. When available a quantity of Fiji bananas is despatched by rail each month from Auckland, and I gathered from retail merchants that no difficulty whatsoever is experienced in disposing of such even at high prices, With letters of introduction from the Hon. the Colonial Secretary, I called on the Director of Agriculture and the Comptroller of Customs. The latter official was not on duty when I called and I had not an opportunity of seeing him before I left the city. I met his deputy, however, and whilst both he and the Director of Agriculture showed me every courtesy neither official could assist me very much in my investigations of local marketing conditions. I had a long and interesting conversation with the Director of Agriculture, Dr. Reakes, who was very sympathetic in his attitude towards importations into New Zealand of Fiji produce.

RETURN TO AUCKLAND FROM WELLINGTON.

9. I returned to Auckland on 28th February and had an opportunity the following day of seeing a shipment of approximately 6,000 cases of

Samoan bananas landed from the New Zealand Government boat " Maui Pomare " an insulated vessel specially constructed for the carriage of fruit. It was interesting to compare the shipment with Fijian consignments of the previous fortnight to Auckland and I regret to record that the condition of the Samoan fruit was by far superior. As near as I could estimate 15 per cent. only was yellow but not over-ripe whilst the remainder appeared to be green and firm.

INVESTIGATIONS REGARDING POSSIBILITIES OF LARGER MARKETS IN NEW ZEALAND FOR FIJI PRODUCE.

10. I employed the remaining few days of my visit to New Zealand investigating possibilities of increased markets for Fiji bananas and other produce and discussed the question with several of the leading fruit agents and merchants in Auckland. Without exception all were most enthusiastic over an extensive development of the banana trade. The public, they contended, are clamouring for bananas and insist on having the Fiji product but at a cheaper price. At present the fruit is an expensive luxury almost outside the reach of the ordinary individual and if conditions remain as they are for much longer merchants claim that the working man, recognised to be the largest consumer will, of necessity, cease to be a purchaser. One of the leading Auckland fruit agents informed me he was satisfied that from 60,000 to 70,000 cases if not more of Fiji bananas placed on the market at a reasonable price would readily be absorbed in New Zealand each month if properly distributed among the larger cities. I do not for a moment doubt this assertion but whilst the public are demanding more fruit they also expect to get it of the best quality. Recent shipments to Auckland have not, I should say, been a good advertisement for Fiji bananas and in my opinion it has been due only to a shortage in the market that little difficulty has been experienced by merchants in making sales. Shippers have, I am afraid, in view of this shortage been too prone to fill cases with indifferent fruit which in normal times would be rejected by them as unsuitable for export and have not considered the necessity of maintaining the highest possible standard in order to foster what should be a much more important industry in the Colony. There would appear to be a very limited demand in New Zealand for tropical fresh fruits other than bananas and whilst I suggested to merchants different varieties which in time could be supplied by Fiji in large quantities if required, they were perfectly candid in stating that the public would not be interested. For citrus there is a good market, oranges, mandarins, Lisbon lemons and grape-fruit being imported in fairly large quantities from Australia and the United States of America. No attempt has been made by Fiji to cater for the citrus trade in New Zealand and I am of opinion that there is an excellent opportunity awaiting growers who would produce the best varieties and grade and pack the fruit in accordance with merchants' requirements. For Fiji vegetables there is not a keen demand. Kumalas and tomatoes would, I was informed, probably find a more ready market than at present during the New Zealand " off " season if the quality was of a higher standard but at the same time merchants warned against over production.

11. I concluded my observations and investigations on 10th March, and left Auckland the following day on the s.s. " Aorangi " for Fiji, arriving in the Colony on 14th March.

12. My thanks are due to many business firms and individuals in New Zealand who rendered me valuable assistance during my investigations.

MOULD DAMAGE TO COPRA.

By W. J. Blackie, M.Sc., Government Chemist.

The experimental results in this paper were found scattered through the records of the Agricultural Department and were obtained by the previous Government Chemist, C. L. Southall. The paper in its present form has been entirely compiled by the author who is responsible for the arrangement, introduction, discussion, interpretation of results and graphic representation. From the results and discussion herein described, experiments are now under way to study methods of alleviation of mould action on copra.

INTRODUCTION.

Copra as prepared by the less efficiently equipped producer in Fiji, is attacked by several species of moulds, notably *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus* species and several species of *Penicillium*. The damage caused by these fungoid growths is in many cases quite considerable and the resultant product finds a poor market. Mould action is not confined to the surface nor does copra appear to be limited to the attack of one definite type of mould, but depending upon the season of the year and apparently on the humidity of the atmosphere which controls in no small way the rate of drying, fungoid growths succeed one another in establishing themselves on the drying material. It is usual to find a preponderance of one definite growth at a time although two or three may have succeeded in establishing themselves. The establishment appears, superficially, to follow a definite order in the majority of cases but this is not always so, and in some cases definite growths fail to make their appearance. Under these conditions it is usual to find copra badly attacked, due no doubt to unchecked development of the fungus through lack of competition; and in five or six days the mycelia especially in the case of *Aspergillus flavus* which appears to be responsible for most of the damage, have penetrated into the meat and decomposition ensues, commencing in proximity to the mycelia and gradually spreading throughout the material.

2. It is usual to note that certain types of drying meat are attacked earlier than others, drying under identical conditions. More especially is this so with germinated material and sometimes spore formation has taken place before the neighbouring meat is attacked. The possible explanation here is that enzymic action with consequent decomposition of fats, proteins, carbohydrates has produced a superficial medium suitable both in available food and hydrogen-ion concentration for the establishment of fungoid growths. In all probability the succession of growths is controlled by the increasing acidity of the material which also has its effect on the fungoid lipases and esterases or fat-splitting enzymes since these complex organic compounds, working under optimum conditions, have a fairly narrow P.H. range. Except in the case of the germinated nut, the surface of the fresh meat is neutral or only faintly acid and therefore it is considered that the work of destruction is commenced by bacteria (since bacterial lipase has its optimum at P.H. 7·2 to 9·0), followed by a definite succession of fungoid growths.

Summarising these observations it appears that mould action is influenced by—

(1) humidity of the atmosphere which controls the rate of drying of the meat, and exposure to rainfall;

(2) the preparation of a suitable superficial medium for the establishment of moulds either (*a*) before drying operations as in the case of the germinated nut or (*b*) through the action of bacteria on the copra;
(3) the presence of sufficient moisture in the drying copra to take part in the hydrolytic processes.

3. Little is known with regard to the mechanism of the chemical reactions taking place during the decomposition of copra by bacterial and mould action. When it is considered that the reactions are taking place upon a complex substrate consisting chiefly of complex glycerides, but containing also protein bodies, various types of nucleotides, simple and complex carbohydrates, including cellulose, and various other products in minute amounts, it is readily understood how involved the problem is. The oil extracted from such copra must contain not only the free fatty acids liberated by the action of the lipase group of enzymes but also many other products resulting from the decomposition of proteins, carbohydrates, &c. About twenty-two or more distinct enzymes have been isolated from moulds (many of them from *Aspergillus niger*) and almost as many from bacteria. Among these are lipase, the fat splitting type, various types which act on carbohydrates such as: maltase, raffinase, cellobiase, lactase, diatase, inulase, emulsin, &c.; types acting on nucleic acids, *e.g.*, nuclease and various types such as oxidase, reductase, catalase, all group-specific in their actions. The activity of these various enzymes is dependent in no small manner on the P.H. of the medium, maximum activity being displayed at definite P.H., slight deviations from which have a marked effect and no doubt many of the products produced act as inhibitors of certain types of reaction. The sum total of these different processes is to produce a coloured oil containing free fatty acids, and, as mentioned above, various other products in small amounts. Moreover the oil cake produced has suffered in nutritional value through loss of proteins and carbohydrates. The oil also develops the property of rancidity due both to further decomposition of the acids produced and also to the presence in it of proteins and other decomposition products. Coconut oil consists of mono, di and triglycerides, of lauric, caproic, caprylic, capric, myristic, palmitic and oleic acids together with small amounts of certain of the esters of phytosterol. With regard to the action of the lipase enzymes on this heterogeneous system, little is known. The composition of the free fatty acids produced has not been determined with any great accuracy. Undoubtedly, certain of the groupings lend themselves more readily to attack than others such as the esters of the unsaturated acids, *e.g.*, oleic, however, although different fats are not attacked at the same rates, owing to the large amounts of lauric acid combinations in the original oil, quantities of this acid would be freed in the oil by enzyme action.

4. In attempting to study the catalytic effects of lipase as a fat splitting enzyme acting on drying copra, one is faced with a varying concentration of substrate, varying hydrogen-ion concentration, and varying temperature. The latter could be controlled and superficially also the P.H. to a limited extent, but variations in substrate concentration and internal P.H. affect the velocity of the enzyme reaction. It would appear also that the accumulation of free acids appears at first to accelerate the reaction of fat splitting, added accumulation of acids slows it down until probably at a definite total free acidity, the enzyme action is destroyed.

This point is illustrated graphically (Graphs 5 and 6), of increase in acidity and logarithum of percentage increase of acids with time. Here it is seen that the amount of free acid reaches a maximum, and then decreases

in value. This decreasing value is to be explained by the utilisation of the free acid by the reverse process of fat formation, or else what appears more likely, their destruction by carboxylase with the production of CO and H_2O. These figures are taken from table (1) and are to be compared with those from table (4) obtained from copra made and stored under commercial conditions.

In graph 6A there is a distinct per cent. increase in acidity up to the 7th day, then a gradual decrease to the 21st day, then a more gradual decrease up to the 28th day. In graph 6B there is a rapid increase up to the 4th day, a more gradual increase from the 4th to the 7th, a more rapid increase comparable with the preliminary stage from the 7th to the 11th day and then a more gradual increase from the 11th to the 14th. This graph is very interesting as it seems to display distinct periods of activity and decline. This either points to (1) definite reactions taking place in order, (2) the establishment and specific action of four different growths, (3) definite equilibria between fat-splitting and acid utilisation. Graph (6C) further amplifies this phenomenon. In this case the logarithm of the per cent. acid increase from step to step is plotted against time. Here it is seen that after the 11th day there is a diminished per cent. acid increase between successive determinations. The four cycles are markedly displayed in this graph.

In order to form some estimate of the damage done to copra by fungoid action the following experiments were arranged and designed to determine the change undergone when copra was exposed to action of various moulds under conditions favourable to these growths.

EXPERIMENTAL METHOD.

Copra was formed from selected mature nuts by sun drying, and the resultant material grated. The meal was mixed thoroughly. The moisture content was determined and a weight equivalent to 15 grams of anhydrous copra weighed into each of 20 petri dishes. The grated copra was then sterilised by superheated steam at 15 lb pressure. Previous experiment showed that this method of sterilisation caused no loss of oil. In order to eliminate variable water content the grated, sterilised material was dried under sterile conditions and the water content of each dish carefully adjusted to 10 per cent. by means of sterile water. Eight of the dishes were then inoculated with a suspension of two species of *Aspergillus* (probably *Asp. flavus* and *Asp. niger*. This diagnosis is only provisional owing to lack of literature to assist identification in the Departmental Library) and *Penicillium glaucum*. The twelve dishes including four uninoculated as controls were placed in a feebly illuminated cupboard.

In order to obtain pure cultures the following method due to Mr. C. H. Wright, a former Government Chemist, was adopted. A sample of badly infected copra was pounded up with sterilised water under sterile conditions and the product used to infect a nutrient agar medium. The growths that resulted were carefully examined and spores from distinct species separated and used to inoculate fresh quantities of agar medium. By several such operations fresh cultures resulted. In order to obtain, as closely as possible, comparative conditions, the following method of inoculating the copra was used. A platinum loop was touched into a mass of spores in the pure cultures and transferred to sterile testubes containing 4 ccs. sterilised water. After thorough mixing one cc. was withdrawn and spread evenly over the copra in each petri dish, one cc. of sterile water without sopres being added to the controls. Necessary adjustments were then made in each case for 10 per cent. moisture content.

Penicillium glaucum did not grow but the species of *Aspergillus* did so luxuriantly during the course of two weeks when a decline set in owing, no doubt, to accumulation of metabolic products. The material was badly attacked by the moulds owing to its physical condition, *i.e.*, increased surface for interaction with the mould enzymes. At the commencement of the experiment the quantity of oil and free fatty acids were determined accurately by analysis of samples from two of the remaining petri dishes also a sample taken from the unsterilised bowl of dessicated coconut. These three analyses gave almost identical results. Two inoculated and one uninoculated dish were withdrawn at the end of one, two, three and four weeks and oil and free fatty acid determined. The oil and free fatty acids were determined in the usual manner and the following results, table (1) obtained:

TABLE 1.

	Copra at Com. Exp.	After 7 days.				After 14 days.			
		Control.	1.	2.	Mean	Control.	1.	2.	Mean
Oil in anhydrous copra %	68·2	68·1	57·7	59·5	58·6	68·1	57·7	52·0	54·9
Acid as oleic in oil .. %	0·3	0·3	5·4	4·9	5·2	0·3	5·1	5·4	5·3
Loss anhydrous copra %	..	..	3·5	3·2	3·4	..	9·0	10·7	9·9
Apparent loss oil .. %	..	..	10·4	8·7	9·6	..	10·5	16·1	13·3
Actual loss oil .. %	..	..	12·5	10·6	11·6	..	15·7	21·7	18·7
Obscured loss oil	..	..	2·1	1·9	2·0	..	5·2	5·6	5·4

TABLE 1—*continued.*

	After 21 days.				After 28 days.			
	Control.	1.	2.	Mean	Control.	1.	2.	Mean
Oil in anhydrous copra .. .. %	68·0	48·8	47·1	48·0	68·2	45·3	49·5	47·4
Acid as oleic in oil .. .. %	0·5	4·1	4·8	4·5	0·4	3·4	3·4	3·4
Loss anhydrous copra .. .. %	..	11·0	16·0	13·5	..	17·3	14·9	16·1
Apparent loss oil .. .. %	..	19·4	21·1	20·3	..	22·9	18·6	20·8
Actual loss oil .. .. .. %	..	24·8	28·6	26·7	..	30·7	26·0	28·4
Obscured loss oil .. .. %	..	5·4	7·6	6·5	..	7·8	7·4	7·6

TABLE 2.

SIMPLYING THE ABOVE TABLE AND TAKING MEAN FIGURES.

Percentage—	*One week.*	*Two weeks.*	*Three weeks.*	*Four weeks.*
Loss anhydrous copra	3·4	9·9	13·5	16·1
Apparent loss oil ..	9·6	13·3	20·3	20·8
Actual loss oil ..	11·6	18·7	26·7	28·4
Obscured loss oil ..	2·0	5·4	6·5	7·6

N.B.—The figures for loss of oil are calculated on anhydrous copra.

On consulting the table, it is to be observed that there may be a variation of as much as 10 per cent. in oil content in anhydrous copra, between the two experimental dishes analysed in each period, probably due to quantity of growth. The mean result is taken in each case and compared with the control which had not varied within the limits of experimental error during the course of the month. The table is self-explanatory and needs no further discussion. Table (2) is a simplification of table (1) taking mean figures.

RESULTS OF EXPERIMENT.

The growth of the two moulds *Aspergillus flavus* and *Asp. niger* on grated coconut containing 10 per cent. moisture over a period of four weeks resulted in—

(1) an apparent loss of 20·8 per cent. of oil, which, corrected for loss of copra, gives an actual loss of 28·4 per cent. oil;
(2) a loss of 16·1 per cent. of anhydrous copra;
(3) an increase in the acidity of oil during the first two weeks of from 0·3 to 5·5 per cent., followed by a decrease in the second two weeks to 3·4 per cent.

2. Concurrently with the above, a second experiment was tried. Copra prepared, shredded, and sterilised as in the first experiment, with its moisture content accurately adjusted to 10 per cent. was exposed on petri dishes for three hours in two bulk copra stores, three dishes in each store. The object of this experiment was to infect copra with spores normally present where copra is stored and to limit the degree of inoculation to a normal amount. After a few days a single mould appeared which seemed to be *Aspergillus flavus* and grew very slowly during the four weeks of the experiment. Control samples unexposed were kept as in experiment (1).

At the end of the period, 28 days, analyses were performed as before and the results are tabulated in Table 3:—

TABLE 3.

	Unexposed.		Exposed copra after 28 days.					
			Store "A."			Store "B."		
	1st day.	28th day.	1.	2.	3.	1.	2.	3.
Oil in anhydrous copra	68·2	68·1	66·7	67·3	64·7	66·9	65·8	66·0
Acid as oleic in oil	0·3	0·4	8·3	7·7	8·4	8·0	8·6	8·6
Loss anhydrous copra	..	..	4·3	3·0	4·1	3·9	3·6	3·6
Apparent loss oil	..	..	1·4	0·8	3·4	1·2	2·3	2·1
Actual loss oil	..	..	4·3	2·9	5·9	3·9	4·7	4·5
Obscured loss oil	..	..	2·9	2·1	2·5	2·7	2·4	2·4

N.B.—The figures for loss of oil are calculated on anhydrous copra.

RESULTS.

1. The actual loss of oil was relatively much less than in the previous experiment amounting to an average figure of 4·4 per cent.

2. The loss of anhydrous copra was much less, amounting to only 3·9 per cent. as an average figure.

3. A very much greater increase in free fatty acid, the average figure amounting to 8·3 per cent.

DISCUSSION OF RESULTS.

1. In considering the first experiment it is to be clearly understood that the results obtained could not be compared in a quantitative way with the results that would be obtained with copra made and stored under commer-

cial conditions. The reason for this is that (1) the density of the material, that is the mass per unit volume, was much less with the grated material than with normal copra.

2. A greatly increased surface was exposed to enzyme action in the case of grated material thus permitting penetration.

3. The cellular structure of the material was largely altered by the grating, thus permitting a more intense enzyme action on fats, carbohydrates, proteins and other bodies contained in copra.

4. The material was sterilised in the first instance and limited to the attack of one definite species of mould.

5. The degree of infection of the mould was much greater than would occur normally owing to unrestricted growth through lack of competition.

6. The moisture content 10 per cent., was initially high. In practice this would be transient since well dried copra averages about 5·5 per cent. in Fiji.

This experiment was designed to obtain the maximum oil loss by providing optimum conditions for mould growth, the moisture content of 10 per cent. being considered favourable to the two species of *Aspergillus*.

In experiment (2) an attempt was made to eliminate the objection discussed in (4) above, by permitting the grated copra to become normally infected with spores present in the atmosphere of the bulk copra stores, but this experiment also suffers both from the objections discussed above and from the fact that—

(*a*) there are very few air-currents present in a copra store, and hence infection by spores is at minimum;

(*b*) several moulds in series had grown on the bulk material during the formation of copra.

Therefore, the type present on the material in the bulk stores had established itself after a series of fungi had interacted with the material and as a result, had become unsuitable for establishment on the grated copra, which had been sterilised and kept free from mould action. This seems to be so from the fact that, although the surface of the grated copra open to interaction was much larger than with normal copra, only one fungus succeeded in establishing itself and grew very slowly during the four weeks of the experiment. From the consideration of the above results it was thought that a fairer estimate of the damage done, could be obtained by determining the losses resulting from copra prepared upon open "Vatas" as practised by producers in Fiji. The intention was to produce copra containing about 10 per cent. free fatty acid, this being the average acidity of Fijian copra, and with this end in view the copra was subjected to somewhat harsh treatment. To prevent evaporation, it was kept covered without much ventilation, when a moisture content of 10 per cent. was reached. This was assumed to correspond to the practice of removing semi-dried copra from the "Vata" to a large heap inside a shed.

DESCRIPTION OF EXPERIMENT.

Eighty-six pounds of fresh cut copra of known composition was spread on a "Vata" protected from rats and mongoose in two separate portions, one containing 50 lb and the other 36 lb. The smaller portion was for the purpose of daily sampling, in order that the approximate condition of the main heap could be determined. Ten pounds of the same copra was dried in a steam oven at about 180° F. Rain fell on the copra for a short time on the 3rd, 4th, 5th, and 9th days. During the night, the material was heaped under galvanised iron.

2. The copra soon became heavily infected with moulds, but they did not penetrate far into the mass until five or six days had elapsed. Mould attack was assisted by copra beetles which, by attacking mouldy spots and making fresh openings, increased the surface of interaction.

3. After fourteen days had elapsed, the copra was dried down to 5 per cent. water, carefully sampled and analysed. The copra prepared in the steam oven yielded the theoretical quantity of anhydrous copra which for the nuts used, amounted to 54 per cent. of the original weight.

TABLE 4.

	Time in days from the commencement of the experiment.							
	1.	3.	4.	7.	9.	11.	13.	14.
Loss of anhydrous copra ..	% ..	% 0·8	% 1·6	% 3·0	% 5·6	% 7·4	% 10·5	% 12·4
Oil in anhydrous copra	67·6	65·7	65·3	65·7	63·1	62·3	60·7	59·4
Actual oil loss	..	1·9	2·3	1·9	4·5	5·3	6·9	8·2
Free acid in oil (as oleic) ..	0·2	0·8	1·6	1·9	3·3	5·7	7·3	8·5

RESULTS OF EXPERIMENT.

1. The total loss of anhydrous copra was 12·4 per cent.

2. The increase in acidity calculated as oleic acid was 8·3 per cent.

3. The brown mould which appeared in quantity after the fifth day, *Aspergillus glaucus*, appeared to cause the most damage.

4. The experiment appeared to indicate that the main loss takes place not on the "Vata" itself but during storage before the moisture content falls below 6 per cent. If this should prove to be correct a much greater loss of copra than the 12·4 per cent. obtained in the experiment appears to be possible in many of the wetter districts.

SUMMARY.

In the introductory portion of this paper an attempt was made to indicate the complexity of the chemical problems connected with the decomposition of copra, chiefly by mould action. It is only by study in this direction and a thorough mycological investigation that attempts can be made, in an enlightened way, to counteract the destruction. From observations made of commercial samples and as a result of the experiments above described, surmises, at the present juncture, with regard to certain features underlying the *modus operandi* of this deterioration are advanced.

It was therein stated that—

(1) the humidity of the atmosphere controls in no small manner the establishment and development of fungoid growths;

(2) that moulds attack the copra in order and that it is usual to find a preponderance of one growth at a time;

(3) that bacterial activity may be a precursor of fungoid activity. This is contrary to results obtained by others. (See Copeland "The Coconut");

(4) that enzyme action is not alone limited to the destruction of the fats;

(5) that a changing hydrogen-ion concentration controls establishment of moulds and the nature of subsequent enzyme action;

(6) that where one growth preponderates under conditions favourable to it, destruction as measured by the decreasing oil content is generally, other things being equal, at a maximum for the experimental period concerned.

(1) With regard to (1) practical experience has definitely shown that drying-copra, on open "Vatas" unprotected from rain, becomes seriously infected with moulds especially if the humidity of the atmosphere limits the rate of drying. It is quite a common thing to notice that copra which under the influence of a spell of dry weather has developed the crackling sound on fracture, also a clean fracture, becomes quite leathery if the drying conditions are changed by a spell of very humid weather. This flacid condition is due to the absorption of moisture. If, as some authors go so far as to maintain, that mould action is definitely controlled by the amount of water present (see Copeland: "The Coconut") then a changing water content would have a marked effect on mould action. This, however, is only apparently so, since changing water content would also mean a greater solution and consequent ionisation of free fatty acid with the production of hydrogen-ions which in an unbuffered solution would mean an increasing actual acidity.

It is essential, in order to prevent or limit mould action, to dry the copra as rapidly as possible to somewhere in the neighbourhood of 5 per cent. at least and this is impossible under high humidity conditions on the open "Vata" with inadequate protection from weather. It might be argued here that rain falling on semi-dried copra has difficulty of penetration but it is to be remembered that superficially the water concentration would be high enough for mould activity and that this superficial concentration would be regulated by the humidity of the atmosphere.

(2) Experiments now being carried out have displayed the fact, as far as superficial examination is able to determine, that it is unusual to find under commercial conditions several moulds attacking copra with equal intensity at the one time. It appears more usual to find a preponderance of one growth and in many cases one growth only actively operating. The appearance of another seems to herald the decline of the actively operating type under observation. If, owing to peculiar conditions in different portions of the meat, several fungi have made their appearance, the growth of each is restricted and stunted.

(3) If a careful observation is made of drying meat it is seen, during the first and second day under humid conditions, that a slight browning may take place in some cases. In others differences are noticed in the colour of the meat at definite positions on the surface although microscopic observation showed few spores and those that were present did not appear to be germinating. It would appear from this that the fungoid spores present could not develop until the surface had been changed in some manner for them. Further microscopic observations showed that when the spores developed they did so in these discloured patches. The reason for considering bacteria as a precursor of fungoid action was stated in the introduction. It might be argued that experiment (1) negatives this surmise since infection of a fungoid on sterilised material resulted in the development of the fungoid growth. But it is to be remembered that the fungoid growth was not sterile with regard to bacteria and also that the material infected was already prepared copra and possibly had already, before sterilisation, been subjected to a preliminary bacterial infection, with an accumulation

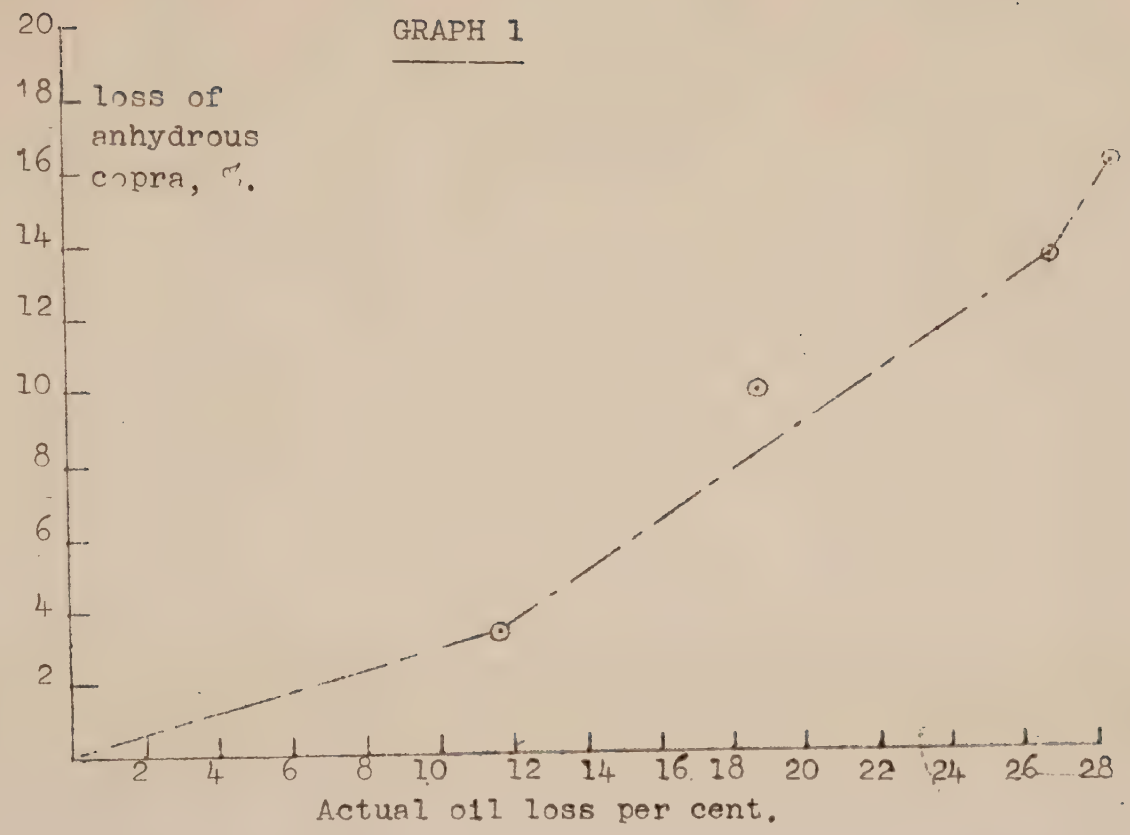
of products necessary for fungoid development. Instead of negativing, experiment (1) tends to support the surmise from the following considerations. The control dishes, after sterilisation, were placed in the same cupboard and in close proximity to the dishes in which *Aspergillus* species was actively growing. Now these controls under the above-mentioned conditions did not change in oil and free fatty acid within the limits of experimental error during the period of the experiment (one month). It is conceivable that spores must have fallen on this control material and it is reasonable to ask why they did not develop. Apparently, the slight acidity 0·3 per cent. was detrimental to bacterial action or rather for the action of those types present in a chemical laboratory since the material remained sterile, (if sterility can be measured by an unchanged substrate) during the experimental period. The only conclusion to be drawn then is that suitable strains of bacteria or suitable products for germination were introduced with the infection on the experimental dishes. The former view seems more acceptable in the light of experiment (2). Here possibilities of obtaining the right strains of the bacteria would be more limited than under exposed conditions or by direct inoculation and it is to be noted that only a single fungus established itself and grew very slowly during the experiment. However, other limiting features are discussed in the results of the experiment. It will be realised how important the proving of this point would be in the control of growths since by suitably sterilising the material it might be possible to either limit the series of reactions or else prevent them entirely. Experiments are now in progress from these points of view.

(4) It is reasonable to suppose since the fats have a high concentration, in the copra and are in an available form that enzyme action would be concentrated on the splitting of these substances. This may be true but it is not correct to believe that enzyme action is limited to these substances. In this connection the following graphs (1) and (2) are interesting. The values used are taken from Tables 1 and 4.

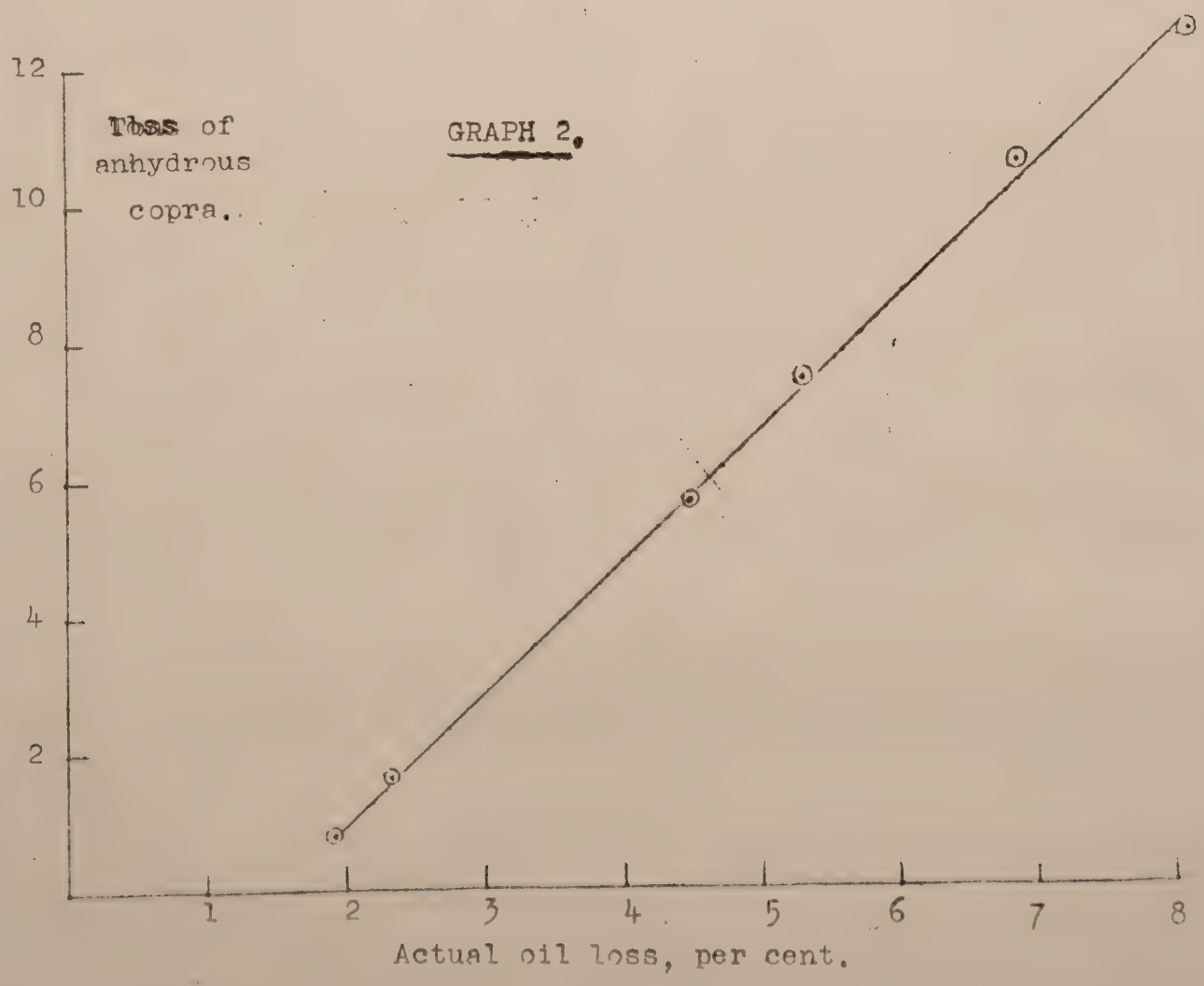
If the destruction of copra is directly proportional to loss in oil then, if corresponding values of per cent. loss of anhydrous copra are plotted against per cent. actual oil loss then a straight line graph should result. On comparing the two graphs it is seen that this is true for the greater number of values in graph (2) and less accurately in graph (1) which suffers from lack of intermediate values. In both graphs it is to be noticed that in the preliminary stages enzyme action is not limited to the decomposition of the fats. It is noticed in graph (2) after the third day when the free acidity has reached the value of 0·8 and when 0·8 per cent. anhydrous copra has been lost that enzyme action appears to be limited to fat splitting. Graph (1) is not strictly comparable owing to reasons (discussed elsewhere) which may account for the slight irregularities. Again it is noticed in graph (3) that the loss of oil is heavier in the case of experiment (1) yet if the loss in anhydrous copra is compared under the same conditions, graph (4) it is seen that they are comparable up to almost the fourteenth day. This shows that copra is being changed at the same rate but that other enzyme besides the lipase group are actively operating and obscuring results.

(5) The reasons for considering this point as a feature in copra destruction was discussed in the introduction of this paper and no doubt is the main point concerned with the prolonged action of moulds permitting, as it does, attack from various species. Experiments now in the course of progress seem to show that by varying the hydrogen-ion concentration of the superficial medium growth is limited and in one particular experiment, greatly restricted. These experiments will form the subject of a further communication.

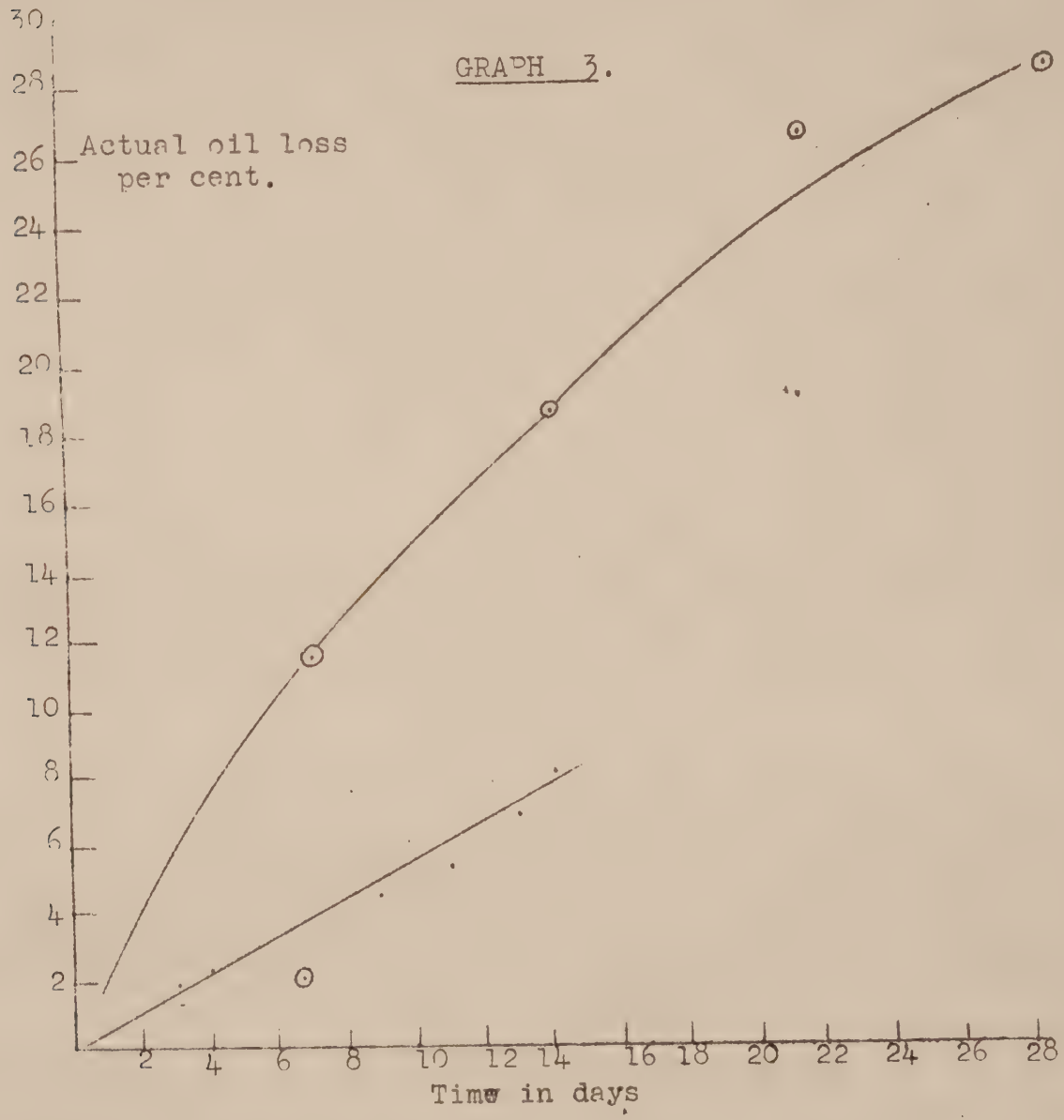
GRAPH 1



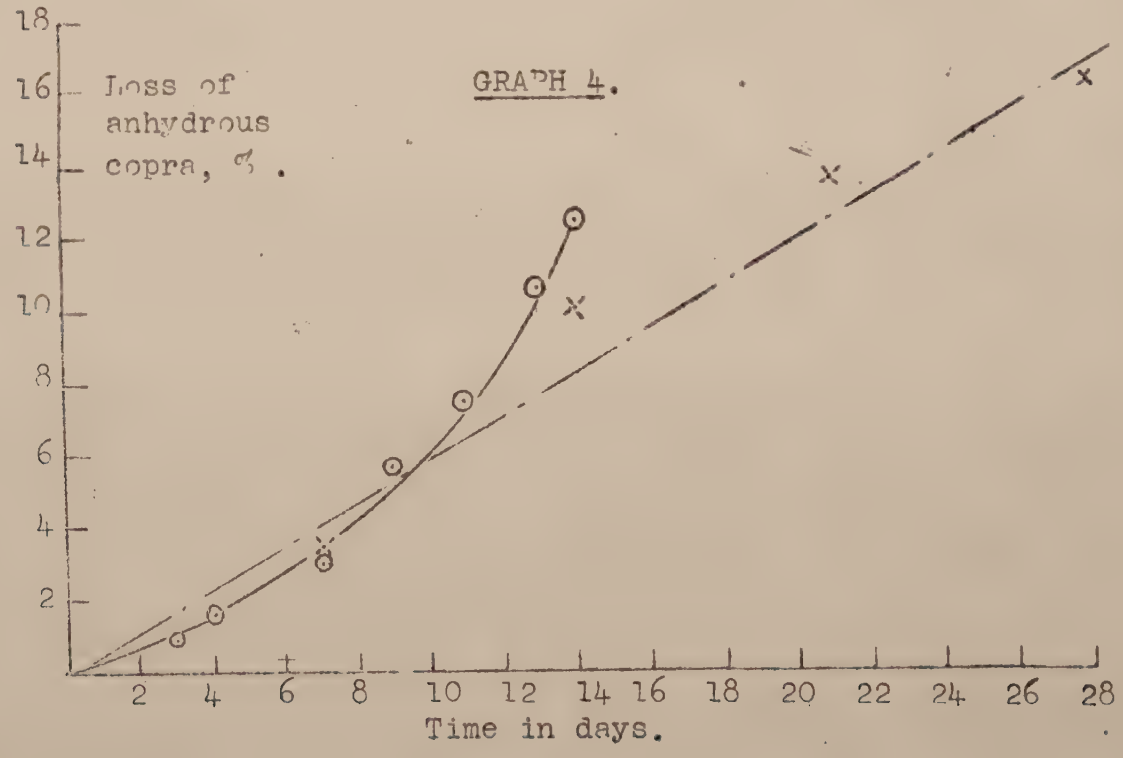
GRAPH 2.



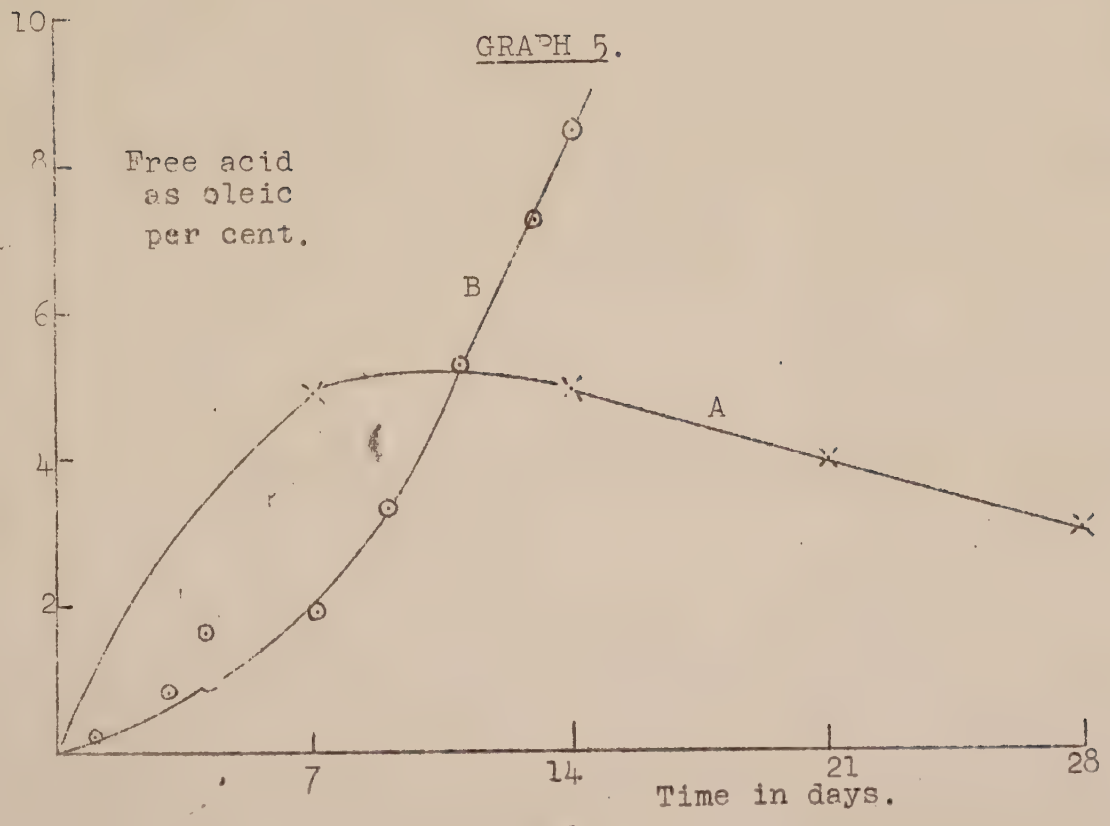
GRAPH 3.



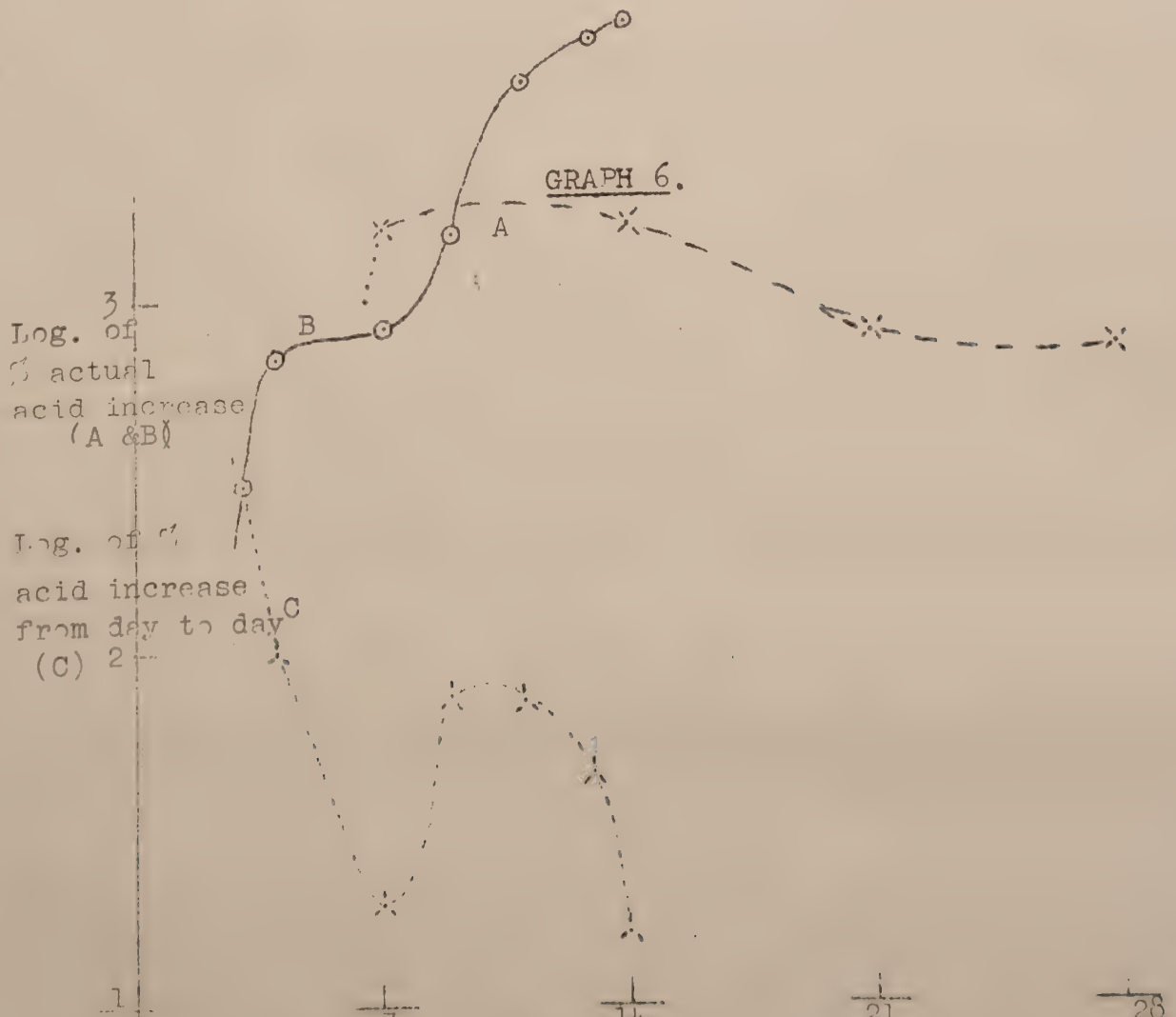
GRAPH 4.



GRAPH 5.



GRAPH 6.



(6) On examining graph (3) it is noticed that the per cent. loss of oil as graphed against the time, shows a great difference in the two cases. In that case where only one fungus is grown the loss of oil is very much greater but begins to fall off between the 21st and 28th day. The same type of graph is displayed in both cases but the loss is more gradual with the copra prepared under commercial conditions. Many objections could be raised here from the points of view previously discussed in comparing these two experiments but observations of commercially made material seem to support this contention. From the graphs it is seen that the loss of oil is almost a function of the time that has elapsed up to at least twenty-one days in the case of experiment (1). Experiment (2) was discontinued at the 14th day.

(7) The production of acids in an unbuffered medium would have, in the presence of sufficient moisture, an effect on the hydrogen-ion concentration. This, of course, is qualified by the nature of the acids and their ionising ability. Therefore this section could be discussed under (6) above. In graph (5A) it is clearly shown that the acidity rises steeply then very gradually until, at the 14th day, it begins to decrease and at the 28th day it has a value corresponding to what it was between the 4th and 5th day (from the graph). This condition is not realised in graph B for copra prepared under commercial conditions. The rates of formation of acids is irregular up to the 7th day when the increase is regular to the 14th and is almost perfectly a function of the time. Peculiar features with regard to graphs A and B are that decreasing acidity (5A) does not correspond to increase oil or rather relatively decreasing oil loss nor does increased acidity (5B) correspond to markedly increasing oil loss.

Undoubtedly this phenomonen requires further confirmation. With regard to experiment (1) the nature of the graph would seem to indicate the point mentioned in the introduction that the disappearance of the free fatty acids points to the action of the enzyme carboxylase.

CONCLUSIONS.

When it is considered how varied are the uses of coconut oil both as a food source and in the soap and allied industries it is understood how essential it is to produce as pure an article as possible, both from the point of view of increased returns and also the cheapening of the manufactured article. If it is considered that the total production of copra in Fiji in 1926 was 27,868 tons and if all this suffered a deterioration from mould action of 12·4 per cent. then the loss to producers amounted to at least £70,974 at the then ruling price of £18 per ton. This loss would be even greater in the wetter districts of the Group. This is serious and attempts to remedy the condition are called for. In the foregoing some attempt has been made with the help of experimentally obtained values to discuss this problem with a view to controlling mould growth. This paper was written primarily to stimulate interest in the subject and also as an introduction to work now in progress in which practical attempts are being made to control this loss, notably by a thorough investigation of the claims made for sulphuring copra as a preventive of fungoid action. It is hoped that these investigations will be of use and of sufficient importance to merit further communications. No doubt many of the points raised and the methods of interpretation of results are controversial nevertheless there are certain grounds, if only tentative for the above discussion; and if interest is stimulated thereby then one of the objects in writing this paper has been satisfied. Undoubtedly a thorough mycological investigation is called for since this is a part of the subject that has been neglected.

Much useful work and investigation has been done in the Philippines on this subject but more is required; also conditions are not altogether similar in each country more especially with regard to the types of organisms attacking the copra and also climatic features.

Recently in the British Chemical Abstracts for March, 1930, page 375, several papers dealing with the action of Aspergillus species on synthetic media, &c., are discussed. In Acta Phytochim (1924, 4, 343–361) H. Tamiya and T. Hida discuss in a very important paper the acid production, respiration, oxidase reaction and reducing power of various species of Aspergillus. Unfortunately the original paper is not available and the abstract is rather short. In the (J. Soc. Chem. Ind. Japan 1929, 32, 306B, 307B, 308B) R. Takata considers among other interesting things the reaction between the hydrogen-ion concentration of the medium and the yield of mycelium and the influence of sodium chloride, sodium sulphate and sugar concentration on the growth of the mycelium. He finds:—

(1) that the maximum yield of mycelium is obtained between P.H. 4·5 and 5·6;

(2) that growth is increased by the addition of sodium chloride and sulphate to the medium in definite concentrations.

We have found that washing "meat" with a 5 to 10 per cent. salt solution with the idea of producing the white mould free copra sometimes obtained by drying the material exposed to sea breezes, produced on drying a very mouldy copra which was completely decomposed after two months storage in a sealed specimen bottle. Controls similarly stored although attacked slightly still yielded after the same time a fair quality copra. The complete decomposition of the material appeared to be due to the action of one mould. These results are interesting and again display the fact that the nature of the superficial medium controls the type of organism that can establish itself and develop.

I am indebted to Mr. Surridge, A.R.C.S. (1) Agronomist to the Coconut Committee, for valued criticism and suggestions.

ENTOMOLOGICAL NOTES.

(i) THE CLIDEMIA THRIPS (*LIOTHRIPS URICHI*, KARNY).

By H. W. Simmonds, F.E.S.

A strong colony of this insect was introduced from Trinidad, to be used against the Curse, *Clidemia hirta*. They landed in good order on 13th March and by the 20th, 5,000 adults had been picked off the plants and placed, half in cages for breeding purposes, and half in the open.

It is proposed to breed the insect up and liberate in the various districts as material becomes available. The effect of the insect is to cause a die-back of the terminal shoots, but not to kill the roots. When the insect is well established, planters will still have to clean their land, but it is hoped that it will so far reduce seeding that reinfestation will seldom take place.

THE LANTANA BUG (*TELEONEMIA LANTANÆ*, DIST.).

This bug, introduced in October, 1928, is now well established in the Suva District. Considerable areas show a yellowing of the foliage, combined with a failure to produce flowers or set seed, whilst in some places it has reached the extent of defoliating the plants.

(ii) BIOLOGICAL CONTROL OF SPATHE-BORER, COCONUT SCALE, AND KOSTER'S CURSE.

By T. H. C. Taylor, B.Sc.

The following notes, which are in the nature of an interim report, may be of interest to planters and others who are personally concerned with these pests.

1.—CONTROL OF TIRATHABA TRICHOGRAMMA—(SPATHE-BORER).

The parasite imported from Java in March, 1930, to combat *Tirathaba*, which is a serious pest of coconuts on every island throughout Fiji, is now being reared in large numbers in captivity. In Java this parasite attacks *Tirathaba rufivena* and *T. mundella*, two moths which are closely allied to the Fiji species, *T. trichogramma*. The latter species is not present in Java; nevertheless the parasite attacks it with avidity in Fiji.

The parasite is *Apanteles tirathabæ*, a small but very active wasp-like insect. It lays its eggs in young larvæ of *Tirathaba* and the resulting grubs feed on the internal organs of the larvæ and kill them after about ten days.

Many difficulties were experienced when the parasites were first imported into Fiji, chiefly owing to the necessity for quarantine for cholera, and the work of distribution has been greatly delayed in consequence. In the latter part of April, however, three colonies were liberated, one at Nasese, near Suva, chiefly for observation purposes, another at Muanicula, Wainunu, and a third in Taveuni, and it is thought that about four colonies will be available for liberation every month from May onwards.

The importation of this parasite, which was the result of the researches of Mr. Paine in Java, marks an important stage in the attempt which is being made to control *Tirathaba* in Fiji. The problem is not so simple as in the case of the Levuana Moth or of the Coconut Scale, both of which now appear to be satisfactorily controlled, but it is hoped that similar results will eventually be achieved in the case of *Tirathaba*. It may, however, be necessary to supplement the activities of the recently imported parasites by importing other species later in the year.

2.—ASPIDIOTUS DESTRUCTOR—(COCONUT SCALE).

A brief inspection of Muanicula Estate on the Wainunu River was made on 30th April, 1930. Large areas on this estate were very heavily infested with scale until 1928, when colonies of the Coccinellid beetle, *Cryptognatha nodiceps*, imported from Trinidad, were liberated. The beetles multiplied extraordinarily rapidly, and early in 1929 the infected coconut palms were all covered with them, so much so that the beetles and their larvæ could easily be seen from the ground on the leaves of the smaller trees.

The scale has now entirely disappeared from all parts of the Muanicula Estate and throughout the Wainunu district. Further, the beetles were liberated at about the same time in all parts of Fiji where scale formerly abounded, notably in the Lomaiviti Group and in the Savusavu district, and in all cases their liberation was followed within a year by the disappearance of the scale.

3.—CLIDEMIA HIRTA—(KOSTER'S CURSE).

Considerable progress has been made in connection with the distribution of the insects imported from Trinidad in the middle of March, 1930, to attack the weed, *Clidemia hirta*.

The insects in question belong to a peculiar group known as Thrips. Their technical name is *Liothrips urichi*, Karny. They are extremely small and are not readily seen with the naked eye. The adult insects are black and of an elongated, torpedo-like, shape. The immature stages are similar in shape to the adults but are bright red in colour, and therefore easily distinguishable from them.

The nature of the damage done to the plants is very apparent in the cages in Suva in which the thrips are being bred. The young leaves at the tips of the branches are attacked first. The insects live entirely on the undersides of the leaves and on the stems, and feed by puncturing the plant tissues, which turn black in the vicinity of each puncture. The resulting black spots are readily apparent on the plants. The attacked leaves and stems soon die and the leaves drop off. The plants are greatly weakened in consequence of the destruction of all the young shoots. In captivity the insects are capable of completely defoliating the plants and killing them outright.

Many large colonies of the trips have already been liberated in the Tailevu district, and others at Nasinu and Lami. In Taveuni three colonies have been liberated, and one at Muanicula, Wainunu. Arrangements are being made to send infected plants to Navua at the beginning of May and others to the Rewa district soon afterwards.

In view of the widespread interest and optimism which have been shown in the activities of these insects it must be pointed out that in spite of their very satisfactory behaviour in captivity no immediate results can be expected on a large scale in the field. Moreover, the work must be regarded purely as an experiment, which is as likely to fail as to succeed. There is now little doubt that the thrips will become established in Fiji, but the areas in which *Clidemia hirta* flourishes are so vast that it will be many months if not years, before the insects multiply and distribute themselves sufficiently to bring about even a partial control of the weed. And at the present stage in the work it is impossible to predict whether they will ever effect an appreciable control.

PRESERVATION OF BOOKS IN THE TROPICS.

By W. J. Blackie, M.Sc., Government Chemist.

A great deal of damage to books and documents results from the united action of insects and moulds. The worst insect offenders in Fiji are undoubtedly the beetle borer and the cockroach; these, by boring or gnawing the covers and printed pages, destroy the book both in appearance and usefulness.

2. In the Agricultural Department many valuable textbooks to which constant reference is being made, also many of the current journals, have been seriously attacked in the past and therefore our endeavours to build up a useful reference library is largely vitiated by the increased cost attending replacement of destroyed volumes. In many cases scientific papers of value, many of which are complimentary copies, cannot be so replaced.

3. In order to minimise this deterioration it is essential—

(1) that the bookcases be closed by tightly-fitting glass doors;

(2) that the air of the bookcases contain the vapour of some volatile chemical deterrent;

(3) that the volumes themselves be treated with some poisonous material which, having no action on the books, prevents insect and mould destruction.

4. With these objects in view the following procedure has been adopted. Two solutions containing the following ingredients were made up:—

Solution (*a*) contained 1 oz. corrosive sublimate, 1½ oz. carbolic acid and one-quart of methylated spirits containing pyridene as one of the denaturing agents.

Solution (*b*) contained 1 oz. of shellac dissolved in 8 ozs. of methylated spirits to which was added 3 drms. of creosote oil.

6. The books were first fumigated with hydrocyanic acid gas to kill spores, &c., then with a flat brush, solution (*a*) was painted on to the covers, inside and out, and generously along the seam dividing the cover from the printed material. After drying, which is quite rapid, the varnish (*b*) was painted on in a similar manner a slight smear being also added to the extremities of the pages, while the book was closed. On drying, the book has a varnished look which does not detract from its appearance. Solution (*a*) must be continually stirred during painting operations in order to obtain an even mixture of corrosive sublimate which has a tendency to settle out.

5. The shelves of the bookcase are also similarly treated with solutions (*a*) and (*b*), and after placing the books back in the case procelain dishes containing paradichlorobenzene are added. A better procedure here would be to drill holes in the shelves at regular intervals and sink in suitable metallic containers for the paradichlorobenzene.

6. For facilitating storage and availability, scientific papers and pamphlets are kept in springback cardboard holders of the box variety. These are treated similarly by painting inside and outside with solutions (*a*) and (*b*) and an envelope containing paradichlorobenzene deposited conveniently inside or fixed with gum to the inside of the lid.

7. This would be a very convenient method for storing and preserving valuable Government documents and Minute Papers.

8. The above described procedure has been only recently adopted but the results attending the use of solution (*b*) by the Veterinary Department have been markedly successful.

9. With regard to frequency of treatment, little can be said as yet, however, once a year should be sufficient.

10. It is necessary to close the bookcase directly after removing or replacing a volume.

GRASSLAND ITS TREATMENT AND MANAGEMENT.

By R. Lindsay Robb, N.D.A., N.D.D., Imperial Chemical Industries Ltd.

PART I.—ESTABLISHMENT OF NEW PASTURES.

POINTS TO AVOID IN PASTURE ESTABLISHMENT.

The most common causes of disappointment in pasture establishment are due to—

(1) using seed mixtures unsuited to the local conditions;
(2) sowing unsuitable strains of plants;
(3) failure to rid the soil of excess moisture;
(4) sowing seeds on weed infested land;
(5) endeavouring to establish a pasture on land "worn out" by continuous cropping without manuring.

All pasture plants may be classified into groups or associations, and each association has a clearly defined set of conditions necessary for development. For successful establishment, therefore, an "association" must be sown to suit the local soil conditions.

The main consideration is the establishment of a sward composed of plants which may thrive under conditions as they exist. This, in all probability, is merely the foundational stage in the development of a future productive pasture and should only be regarded as such.

It is quite futile to attempt the formation of good pasture on water logged land, and money spent on seeds and manures is simply wasted until the excess moisture has been removed. Admittedly draining is a costly operation, but if land is water logged, the ever-recurring expense of seeding and manuring cannot be remunerative until the cause of the trouble—excess moisture—is removed.

CLEAN SEED BED.

The importance of clean land cannot be over-estimated in laying down land to grass. The weed competition may be serious enough for the first year or two on land which appears to be reasonably clean, but where conditions have not permitted of thorough cleaning prior to sowing the seeds, there is a very real danger of the weeds gaining the upper hand before the legitimate plants have been able to establish themselves. Land which may have been continually "white" cropped for a number of years without adequate manuring, always presents serious difficulties for good pasture establishment. The standard of fertility is low, and weeds adapted to this condition generally abound. Thorough cleaning and very generous manurial treatment are essential if a good pasture is to be obtained under such conditions.

VALUE OF SOWING PERSISTENT STRAINS.

Assuming that the land is clean and in good heart, it is important to secure strains of plants which are productive and highly persistent. The leaf is the richest and most nutritious part of the plant.

MANURING WHEN LAYING DOWN.

Liberal manuring of newly laid down pastures is highly important right from the earliest stages of development, and, where practiced, may permit of the establishment of high fertility demanding plants like perennial ryegrass and white clover under comparatively low standards of soil fertility. The importance of persistent strains of plants cannot be over-emphasised, as their response to and development by manurial applications is such, that the cost of manuring is relatively much less than on pastures comprised largely of short-lived and unresponsive plants.

PART II.—MAINTENANCE OF ESTABLISHED PASTURES.

SECONDARY GROWTH.

Large areas of grazing land in New Zealand are not giving of their best, because of the invasion of secondary growth. To effectively deal with this menace is extremely difficult, especially where the value of the land does not permit of much economic expenditure on labour and stock. The more extensive use of cattle to eat down the rank growth along with subdivision, and the use of suitable fertilizers to improve the quality of the herbage offers, perhaps, the most effective means of combating this difficulty.

DRAINING.

The need for removal of excess moisture has already been alluded to in Part I. There are, however, large areas of established pastures of comparatively low productivity because the land is in need of draining. Wet land encourages the growth of weeds and non-nutritious plants of an unpa-

latable nature; spring growth is delayed and grazing during the wetter part of the season is very difficult on account of the hoof damage done by the stock. Draining is often the means of converting this poor grazing land into highly productive pastures, and unfortunately, until this is done, the grazing value is almost negligible. The clearing of ditches and water furrowing in some cases will, to some extent, minimise the losses on poorly drained land. One of the most important features of drainage is to allow for heavier intermittent stocking to be carried out. The land, in an undrained condition is perhaps capable of producing an abundance of grass, but its utilisation becomes a matter of the greatest difficulty. Heavy stocking of wet land often results in the ruin of the pasture.

GRAZING AND MOWING.

While young pastures should not be too severely grazed in their early stages of development, the over-grazing of rapidly growing grass on established pastures, under high fertility conditions, is hardly possible, but may easily take place when fertility factors are not continuously high. The old method of leaving too much grass unconsumed during the late summer and autumn to supply winter grazing is not to be recommended, as the quality of the feed is extremely low and the rough grass suppresses and delays the new growth in spring.

Mixed grazing or grazing different types of stock over the paddocks keeps the pastures in better condition than grazing with one class of stock only. Horses are very selective in their grazing and the herbage soon becomes rough and tufted when they are the sole grazing stock. Sheep are also selective grazers, and confine themselves entirely to the short fine plants, whereas cattle are much less discriminating in their choice of the herbage plants.

As grass is nutritious in direct proportion as it is young, immature, and the product of rapid growth, the feeding of pastures when the herbage is short cannot be too strongly recommended, but this aspect of the question is more fully discussed later under intensive management.

If the stock cannot utilise all the grass, the mowing machine should be used to remove the surplus growth before any deterioration of the herbage takes place. By this means, the finer bottom grasses and clovers may develop freely when otherwise they may be suppressed almost to the point of extinction.

HARROWING.

The possibilities of effecting improvement in the pastures by more extensive use of the right type of harrows are very great. The chain harrow is useful for spreading animal droppings during the grazing season but quite ineffective as a cultivator. A severe tine harrow during the autumn or winter will assist in the removal of unconsumed grass or dead matter which may have accumulated, and will also improve the aeration of the soil. This greatly facilitates the action of any fertilisers which may be applied rendering them much more effective than if applied on rough unharrowed land. During recent years stronger and better types of harrows for grassland have been evolved and they are proving of great value throughout the grazing areas. The degree of severity of harrowing which is necessary will naturally vary according to the age of the pasture, the efficiency of past grazing, the amount of "dead" growth and condition of the turf.

CONSOLIDATION—HOOF CULTIVATION.

The improvement effected by the consolidation of grazing stock or "hoof cultivation" has often been very marked on grassland throughout

New Zealand. This has been specially noticeable on phosphatic topdressed pastures of the poorer types. The consolidation effected by the treading of the animals appear to facilitate root development of the herbage plants and finally produces a sward of pleasing density. An occasional rolling of the pastures is highly beneficial, but to be effective it must be done when conditions are suitable.

FENCING.

Proper and adequate fencing is a very substantial aid to the securing of maximum returns from grassland. Closer subdivision is urgently required on many areas in order that the grazing may be better controlled. When subdividing, it is advisable to fence, as far as possible, land of the same type. Various types of pasture in the same paddock are not conducive to efficient grazing. The question of fencing is more fully discussed in Part III.

LIMING.

Lime deficiency is one of the most serious limiting factors in the production of good grassland in the Dominion. Fortunately the practice of liming pastures is extending, but the rate could be greatly accelerated with advantage. Soil acidity and lack of lime, limits the species of pastures plants that thrive on any particular area. Further, those that thrive, are not so nutritious as they might be.

Even when lime does not materially increase the bulk of herbage on grassland, it usually beneficially influences the quality. The lack of response of many soils to phosphatic manuring is due to lack of lime. When there is no response of clovers to soluble phosphates, an application of lime should be tried. Even on limestone soils, a surface application of lime is often profitable, as the lime "in situ" may be too deep to sweeten the surface soil layers. Where intensive manuring is practised, liming should be carried out at suitable intervals. The effect of liming pastures reacts beneficially on the health of livestock. Ground carbonate is the popular form of lime to apply. The finer the grinding and the softer the lime, provided the analysis is high, the better. From 10 to 20 cwt. per acre of ground carbonate is a usual dressing, and the autumn and early winter is the best time to apply it. Limited pastures are more drought resistant than grassland which has not been limed, the clovers particularly and also the grasses making better growth during the dry period than on the unlimed area.

TOPDRESSING WITH PHOSPHATES.

Although in recent years there has been a big expansion in the topdressing of pasture lands with phosphatic manures, there is ample room for an extension of this commendable practice. New Zealand soils are short in phosphates, and there are few areas that do not repay an application of phosphatic manures. On many soils the stimulation of grasses, and particularly clovers, with a manure like superphosphate is indeed remarkable. Fortunately, not only is the quantity of herbage increased, but the quality is greatly improved. The better types of grasses thrive at the expense of the coarser species under topdressing, while the health of stock is generally improved, such complaints as bone-chewing being eliminated. From 2 to 3 cwts. per acre—in some districts twice a year—of superphosphate, is a popular dressing.

In certain districts, basic slag gives good results, and in recent years there has been an expansion in the use of Ground Rock Phosphates.

As to time of application, the tendency almost throughout New Zealand, but more particularly in the North Island, is to make the application of phosphates in March–April, so as to increase the autumn and early winter growth

of the pastures. A growing tendency also is to put on a second application in the spring. Where the summer rainfall is satisfactory, a late spring, or even early summer, application is being favoured nowadays to stimulate the growth of the pasture over the difficult December, January–February period. At this time of the year, a soluble phosphate, such as Super, is usually applied.

Topdressing with phosphates has been extended to the hill country, and, if the pastures of New Zealand are to be maintained in a profitable condition, the use of phosphates on grassland must continue to increase in intensity.

THE PLACE OF POTASH.

Potassic manures are annually growing in popularity in New Zealand. In some parts, such as Southland, their use has shown a very marked increase in recent years. Parts of the North Island, particularly peat swampy areas, *e.g.*, Taupiri in the Waikato, need potash also.

Intensive manurial trials, particularly under the new system of grassland management, will doubtless reveal many areas where potash manures can be profitably used in conjunction with other types of fertilizers. Light sandy and peaty soils are frequently deficient in potash.

Potash aids clover growth, and assists pasture plants in the dry periods. In some areas it is noticeable that stock more closely graze the parts of a pasture treated with potash.

The usual form for pasture is 30 per cent. potash salts and from one to two cwts. per acre can be applied.

PART III.—INTENSIVE MANAGEMENT OF GRASSLAND.

Grassland management has too long been regarded merely as a proposition of topdressing and the movement of stock.

It is not that these factors are in themselves unimportant, but they are hopelessly incomplete where maximum economic production is—or should be—the object in view.

The real aim in pasture management may be summed up briefly as the maximum production of herbage of the highest possible quality and its most complete utilization on the farm. This may be a difficult ideal to attain, but in a country like New Zealand where the chief raw material—and source of wealth—is grassland, it is an ideal which every farmer should keep constantly before him.

The main difficulties of the grassland farmer are, first of all, that he has more grass at certain periods of the year than his stock can consume, and secondly, too little at other periods to meet the stock requirements. The stock-carrying capacity of any farm is based on the number that can be carried during the lowest period of grass production, with the result that, during periods of abundance, the pastures are hopelessly undergrazed and the herbage rapidly deteriorates in quality.

New methods of pasture management known as the "New System" have been in operation in Great Britain and Western Europe for some years. This system has as its aim the ideals already referred to regarding production, quality and utilization of the herbage. It introduces several new features and may be regarded as a combination of the following:—

(1) Complete balanced manuring.
(2) Controlled rotational grazing.
(3) Systematic cultural treatment.
(4) Maximum conversion of herbage into animal products with all surplus made into ensilage and hay.

The system is based on sound scientific principles. Short young grass is richer in digestible protein and minerals and of higher feeding value than grass which has been allowed to grow long. By keeping the herbage consistently short and young, the high feeding value may be maintained throughout the whole season.

One of the vital factors of the system, therefore, is to maintain the pastures in their young and leafy state at all periods of the grazing season. This can only be done under a system of intermittent or rotational grazing and " spelling " and by the appliation of suitable fertilizers.

In order that the herbage may be utilised most effectively it must be consumed fairly quickly when it is very short as it will rapidly advance in growth to a less nutritious stage of lower protein and higher fibre content with decreased palatability. For efficient consumption of herbage relatively large numbers of stock are necessary on comparatively small areas, the stock being moved round the paddocks in rotation.

ROTATIONAL GRAZING.

It is clear that the adoption of intensive methods may necessitate a certain amount of subdivision of large areas into smaller paddocks and this is an important consideration, in view of the cost involved.

Control of grazing may, however, be regarded as the master factor in grassland management, and any expense incurred in the erection of fencing to secure this necessary control will be more than justified by the results The size of a paddock under intensive management is really more a question of numbers of stock than actual acreage. The question of acreage is immaterial so long as the area to be grazed bears a proper relationship to the number of grazing animals. For New Zealand conditions it would appear that the relationship of land to stock (cattle) is twelve to fifteen cows per acre with a sufficient number of paddocks to form a complete grazing cycle.

Thus, on a dairy farm of 30 cows with a carrying capacity of one cow per acre, twelve two-and-a-half acre paddocks would be the ideal number. This, however, may be taken as a guiding figure and might have to be slightly modified according to special climatic conditions and composition of the pasture sward.

This question of size of paddock is of much greater significance than it appears on the surface because the principle of half the number twice as large having the same capacity as double the number half the size does not apply under intensive grazing. In other words, ten paddocks of three acres each have a greater stock-carrying capacity than the same area in five paddocks of six acres each. This has been shown conclusively on a number of farms by the increased grazing obtained after subdivision.

The grazing rotationally of small areas by relatively large numbers of stock necessitates frequent movement of the animals and this movement must take place before there is any decline in the milk yield. A three-acre paddock may carry 40 cows for two or three days, but a six-acre paddock will not carry the same stock for double this period because the wastage of herbage due to trampling, fouling, &c., is relatively higher in the larger paddocks.

It is important therefore, where any subdivision is contemplated, to keep closely in view the ultimate maximum stock-carrying capacity and arrange the size of the paddocks accordingly. For New Zealand conditions the number of cows divided by fifteen (intensive carrying capacity per acre) will usually give the acreage of the paddocks, *e.g.*, 60/15 cow farm equals four acre paddocks.

If the stock-carrying capacity over the whole area was one cow per acre under a more or less continuous system of grazing, the fifteen-four acre paddocks here, under systematic rotational grazing, would provide in addition some ensilage and hay.

LAYOUT OF PADDOCKS.

The " layout " of paddocks for intensive management is important and the aim should be ease and economy of labour in moving the stock. The ideal arrangement is the double line of paddocks with a central " race " which should be of sufficient width to obviate any undue risk of " puddling " or " poaching " by the treading of the animals during wet weather. For reasons which are discussed later, it is advisable to have communicating gates between the different paddocks.

It is not advisable of course to subdivide the whole farm at once but to do so gradually as experience proves the value of the smaller areas and more effective control of the grazing. Thus by the time the whole or greater part of the farm is closely subdivided, the experience gained in the intensive management of a few small paddocks will be of inestimable value when the larger number are brought into the scheme.

WATER SUPPLY.

A supply of wholesome water is essential for grazing stock if the best results are to be obtained. Substantial economies can often be effected in the laying on of water by arranging any necessary subdivision to utilise existing supplies and making one trough suffice for two or more paddocks. Where natural supplies are unavailable an endeavour should be made to equip each paddock with water in order to facilitate the control of the grazing. Many pastures carry an inferior type of sward because they can only be grazed at certain periods when the stock can have access to water supplies.

THE PLACE OF NITROGEN IN MANURING OF GRASSLAND.

Owing to its frequent misuse in the past, nitrogen, until comparatively recently, was not regarded with favour as a fertilizer for grassland. The reason is not difficult to explain. Nitrogen is only one of many constituents which are essential for the growth of all farm crops, of which the most important in New Zealand is grass. There are, however, other constituents which are equally necessary for the growth of plants and the most important to the farmer, in addition to the nitrogen, are the phosphates, lime and potash. Nitrogen is, however, such a dominant factor in plant growth that if applied alone it will increase the yield of a crop.

Its continued application alone, however, over a period of years and the increased yields produced by its stimulation will ultimately give riase to a condition of soil in which one or more of the other essentials (phosphates, potash and lime) are so deficient that satisfactory growth becomes impossible. The strength of a chain always depends on the weakest link and so also does the yield of any crop depend on the essential for growth which is present in the smallest quantity.

BALANCED MANURING.

The fundamental principles of manuring are the maintenance of the balance of lime in the soil and the application of phosphates, potash and nitrogen in forms and quantities and at suitable periods which ensure maximum economic returns without any injurious effects to the soil.

It is clear therefore that nitrogen should not be used as the sole fertilizing ingredient, but in combination with phosphates, potash and lime, as

all four are being continually removed by the production of milk, meat, mutton and wool, and consequently all must be returned to the soil if fertility and high production are to be maintained.

It is not necessary, however, to apply phosphates, potash and lime at the same time as a dressing of nitrogen is given. As a matter of fact, it is often advisable to apply the mineral manures (phosphates, potash and lime) at different periods to that of nitrogen.

The application of nitrogen by itself must not be confused with applying nitrogen alone. Nitrogen alone means its application without phosphates, potash and lime, which is fundamentally wrong, but nitrogen by itself may be highly advantageous so long as the phosphates lime and potash have already been applied.

Phosphates, as already indicated, have played a wonderful part in improving the grasslands of New Zealand and in raising the standard of production.

THE ROLF OF NITROGEN.

Can nitrogen, in addition to the other necesssary mineral manures, still further increase economic production in New Zealand? This question is of great importance to the Dominion farmers and the answer is being sought in the numerous manuring and grazing trials which are being conducted in New Zealand by the Department of Agriculture. From the work already done, there are indications that nitrogen, judiciously used, may become a factor of great importance in the economic development of the grasslands of this country.

IMPORTANCE OF EARLY SPRING GRASS.

Under existing conditions throughout the Dominion, the grass available during the months of August and September is generally insufficient to provide for full yields of milk, and in many cases it is largely utilised, not in the production of butter fat, but in building up the constitution of the cows. This is especially the case where the cows come down to calving in poor condition. For high production, early calving, constitutional fitness at time of calving, and ample grass supplies at the beginning of the lactation are essential conditions.

Early calving appears to be an essential condition to high butter fat production. The two opening months (August and September) probably constitutes the most important period in the whole lactation, and this period at present is one of comparatively low production. If cows are reasonably fit when they calve down at the end of July or beginning of August with plenty of grass available for full yields of milk, the total production per cow would be greatly increased. Better winter feeding is of course absolutely necessary if full yields are to be obtained from the beginning of the lactation.

From experience already gained in the more intensive management of grassland, it is perfectly clear that efficient control of the grazing leads to a complete elimination of pasture weeds. The fact that all herbage is consumed (or mown off) when it is short, prevents the seeding and consequent spreading of weed plants which tend to overrun many "continuously" grazed pastures at present. The beneficial results of this greater weed control are very significant as the legitimate plants have not only greater freedom for development, but also benefit from the extra food material in the soil which was formerly utilised by the weeds.

TIME OF APPLYING NITROGEN.

Because of its possibilities in increasing the growth of grass in August and September, nitrogen is likely to become a factor of great importance on the dairy farming of New Zealand. For this purpose, the indications are that it should be applied as a straight dressing during the month of June or early July after the necessary mineral manures have been applied. The month of July and early August is probably the period of the year when it is most difficult to induce growth because of the naturally unfavourable conditions. It is important, therefore, that the dressing of nitrogen given should be sufficient for the purpose required, and from experience already gained it would appear that from 1½ to 2 cwts. per acre of sulphate of ammonia, or its equivalent in any other suitable nitrogenous manure is about the right apount at this stage.

It is difficult to lay down any hard and fast rules regarding the application of sulphate of ammonia for the purpose of securing an "early bite." The normal period of spring growth varies with different districts and it may even vary on different farms in the same district, depending on the soil and the composition of the pasture sward. For instance, on dry land, the spring growth is earlier than on land even in the same locality which becomes waterlogged during the winter months.

As a guide to the time of applying nitrogen, the following procedure may be of interest. If the spring growth of grass on a particular paddock normally occurs in early September and early grass is wanted by the beginning of August, sulphate of ammonia can be applied from the middle to the end of June. On the other hand, if the normal first growth occurs in October, an application of sulphate of ammonia may be applied with advantage in early August to bring forward the grazing to September.

It is clear that a small dressing applied when conditions for growth are unfavourable, may produce very little result, whereas the larger dressing suggested is likely to produce an excellent growth of grass when it is most difficult to secure and consequently of greatest value on the farm.

During the months of October, November and December, the natural rate of growth is sufficient to produce all the grass necessary without any artificial assistance, and the problem then is one more of utilisation than production.

In January and February there is generally a period of comparative scarcity of grass due to the rapid decline of growth through lack of moisture. How far can nitrogen, if at all, increase the grass growth during this period? A definite answer to this question cannot be given until further experimental work has been done. The limiting growth factor at this stage of the season is generally moisture supply, and the question of increasing the production of grass by manuring is more speculative than at other seasons of the year when the rainfall is more reliable.

CONTROLLED GRAZING.

One of the chief problems, and perhaps one of the greatest difficulties in the management of grassland, is that of controlling the grazing, and failure in this respect has been responsible for the ruin of many pastures. If the grass growth was more or less uniform throughout the season, the control of the grazing would be a comparatively easy matter, but unfortunately this is not the case, and of course, it is quite impracticable to vary the numbers of stock according to the amount of feed available at different periods of the grazing season.

The question of regulating the supplies of grass throughout the year, by increasing growth during periods of low production, has already been discussed, and there are certainly distinct possibilities in this direction. The higher the stock-carrying capacity can be raised during the winter and early spring months, the less difficult it becomes to control the wealth of feed produced during the " flush " period later in the season.

It is important that each paddock should be grazed bare in turn, as any grass left uneaten is not only lost from a grazing point of view, but it retards the continued development of fresh and succulent herbage. To facilitate clean grazing, the paddocks should be stocked when the grass is very short.

It is important to realise that, under intensive management, short young grass is a " green concentrate " rich in minerals, and should therefore be converted into animal products as far as possible. In other words, the wastage due to treading, fouling, &c., should be reduced to the minimum.

" ON " AND " OFF " METHOD OF GRAZING.

The ideal method of grazing is accomplished by moving the animals in such a way that the maximum use is made of the herbage with the minimum of trampling and fouling. After about one and a half hours' grazing in the morning, the dairy cow has consumed sufficient for her immediate requirements, and she then lies down to rest and ruminate. The wastage due to the cows lying on good grass is very considerable, apart from the fouling of the pasture when the animals rise again. They should therefore be moved on to a well grazed paddock just before they would lie down to rest. After mid-day, they would again go into the " feeding " paddock for an hour or so and then back again to the well grazed resting paddock. After the evening milking, they would again have an hour and a half to two hours in the " feeding " paddock prior to being moved to the resting (bare) paddock for the night.

This suggested system of grazing explains the need—referred to previously—for having communicating gates between the different paddocks. A certain amount of labour is of course involved in the carrying out of the " on and off " method of grazing, but the stock-carrying capacity is increased by the more efficient rationing of the feed, and hence its more complete utilisation. It is a system which should appeal to those who favour the " night " paddock, as any paddocks convenient to the milking shed may be used to serve as " resting " paddocks.

GRADING OF GRAZING STOCK.

Another method of grazing which is favoured is that of grading the stock into two lots according to their economic importance. On a dairy farm, the milking cows take precedence in the grazing scheme, and as soon as a paddock can no longer maintain the milk yield, they are moved on to a fresh one and their place taken by dry stock—uncalved cows, heifers, &c.—which follow up and complete the grazing. The light harrowing to spread the animal droppings during the season, should be done as frequently as necessary.

In this way, the paddocks are grazed and " spelled " in rotation, and while it is a great improvement on the old method of continuous grazing, it does not permit of the same degree of efficient rationing or so complete utilisation of the feed as the " on and off " method.

UTILISING SURPLUS GRASS.—ENSILAGE.

During periods of abundance of feed, the stock available may be incapable of utilising all the grass. These are critical periods of the grazing

season because failure to remove herbage not required by the stock will result in rapid deterioration of the pastures. The clovers and finer grasses become suppressed by the rapid-growing stronger species, and the result, after a period of bad management, is a rough " open " type of pasture with the ultimate elimination of the leguminous plants.

The obvious remedy is to remove the herbage before it reaches this stage and make it into ensilage or hay. By so doing a valuable foodstuff is conserved for use during periods of scarcity and the pasture remains in excellent condition.

In any case it is essential to make provision against possible prolonged droughts or other abnormal conditions, and the conversion of the surplus grass into ensilage is undoubtedly one of the best means of storing up this necessary reserve.

" CATCH " CROPS UNCERTAIN.

The growing of supplementary catch crops to provide " feed " during low periods of grass production is one of doubtful economy. The labour involved in the production of these crops is expensive and moreover they are seldom ready for use just when they are most required.

(From "Grassland, its Treatment and Management" by R. Lindsay Robb, N.D.A., N.D.D., Imperial Chemical Industries Ltd.)

NOXIOUS WEEDS.

By A. C. Barnes, F.I.C., B.Sc., A.M.I.Ch.E.,
Superintendent of Agriculture.

The problem of controlling the growth of noxious weeds is increasing in importance. Agricultural operations in Fiji, whether conducted by Europeans, Fijians, or Indians, involve a continuous struggle to combat the inroads of such objectionable plants as Koster's Curse (*Clidemia hirta*), Lantana, and Prickly Solanum (*Solanum torvum*). Even on lands under continuous cultivation the menace is serious, but when pasture lands, and rich areas of undeveloped country are seen to be heavily infested with these plants, it cannot but be realised that an early and determined effort is necessary to secure some measure of control. For years it has been known that this question must be tackled in no uncertain manner, and though sporadic efforts have been made; though legislation has been resorted to; and much time and effort spent in various directions, still the areas covered by noxious weeds go on increasing.

Development of the dairying and stock-raising industries is being retarded and the costs of maintaining arable land in cultivation are increasing. Production is held in check and the agricultural community views with dismay the luxuriant growth of noxious weeds. The weeds flower, seed, and spread, practically unchecked by enemies of any kind whatsoever. Occasionally one sees patches of land where the careful work of years has rendered the weeds less obtrusive and in properly cultivated areas, particularly those cropped by the Colonial Sugar Refining Company Limited, and its tenants, they are perhaps of minor importance owing to the system of cane cultivation practised.

The noxious weed problem is by no means new in the Islands of the Pacific. Darwin in " The Voyage of H.M.S. ' Beagle,' " recorded the spread of imported guava in Tahiti to such an extent that it became an objectionable weed a century ago.

Much is expected from the importation of a thrips from Trinidad to control Koester's Curse. We must, however, patiently await the results of the trials, and even these, if successful can lead but to a retardation of the spread of the plant for some time, though we may reasonably hope for a diminution of its incidence in a few years. Doubtless biological control will be an important factor in checking the growth of this weed, but complete eradication is, it is feared, too much to anticipate.

Let us then ask ourselves what are the possible methods of controlling and reducing the incidence of the noxious weeds of Fiji? The following suggest themselves:—

(1) Complete clearing followed by cultivation; applicable to land intended for periodical cropping.

(2) Clearing, cultivation and grassing, with the periodical cutting by hand or machine of noxious weeds in the early stages of growth; as on pasture lands.

(3) Biological control. This has yet to be tested and in any case is not likely to remove the obligation upon the land worker of initial clearing of weeds.

(4) Prevention of seeding of weed plants by slashing before they flower on uncultivated lands not used for pasturage.

(5) Suppression by use of cover crops of a beneficial kind.

(6) The use of weed killers.

Experimental investigations are being carried out by the Department of Agriculture, but these need time to attain a stage when definite instructions in regard to any given local conditions can be given. There are, however, numerous planters and stockmen who have themselves dealt with the noxious weed problem on their land, in many cases with considerable success. These persons are now requested to record their experiences for the benefit of others. The matter is of such grave importance that it is felt that all who may have attempted to solve the problem for themselves whether successfully or otherwise, will readily state their experiences in the realisation that the menace must be co-operatively grappled with if it is to be combatted with success.

A questionnaire is attached for the guidance of those interested. It may be returned completed, or a brief statement forwarded instead. The object is to endeavour to evolve a cheap and effective means of controlling the various noxious weeds throughout the Colony. Climate and soil differ widely in the Group and methods applicable to one plant or one set of conditions may not be suited to others. Suggestions whether based on experience or not will be welcomed, as also will references to literature in the subject of weed control.

I confidently appeal for the assistance of the whole of the European agricultural community, in the first instance for the collection of information and later, when definite plans have been formulated, for a determined co-operative effort directed towards the control of noxious weeds. Any person who desires that his name be not published in connection with the information he supplies is assured that his wish will be respected.

Replies should be addressed to the Superintendent of Agriculture, Suva, and should be plainly marked "Noxious Weeds." They will be transmitted post free.

NOXIOUS WEED CONTROL—QUESTIONNAIRE.

1. Province.
2. District and name of property.
3. Area: Total . acres—
   Under pasture.
   Arable.
   Hill.
   Swamp.
4. Crops grown.
5. Degree of infestation of noxious weeds. Give common names, and state whether dense, sparse, or negligible; type of land and nature of soils on which the weeds grow.
6. What method(s) do you adopt for—
   (*a*) clearing and cultivating land for periodical cropping ?
   (*b*) clearing and cultivating for the establishment of pasture ?
7. What is the cost per acre of the initial clearing of noxious weeds on your land ? (Give names of weeds.)
8. How do you keep noxious weeds in check on ?—
   (*a*) Arable land.
   (*b*) Pasture.
   (*c*) Unused areas.
9. What is the annual cost per acre incurred by controlling noxious weeds under heads 8 (*a*), (*b*) and (*c*) ?
10. Are noxious weeds increasing or diminishing on your land and in your district ?
    Mention names of weeds.
11. Have you observed any factors which encourage or discourage the spread of weeds ? If so, please describe them.
12. Please state any methods based on experience or observation which in your opinion are suited to the control and eradication of particular noxious weeds ?

Signed:

Date: . 1930.

"ADCO" MANURE.

A Paper read by Mr. AUTON, at the General Meeting of the Agricultural Society of Trinidad and Tobago, 10th February, 1927.

THE soil is the essential medium for the production of crops and although some soils are naturally rich in potential resources there are few which can be cropped economically without the addition of manure. Hence a study of the material which must be added to the soil to increase or maintain its fertility is of the greatest importance to the cultivator.

From time immemorial the standard method of enriching the soil in all the countries has been by the use of stable manure or farmyard manure. With the extensive displacement of the animal by mechanical transport the supply of this type of manure has gradually diminished and growers are faced with the problem of finding a suitable substitute. In looking round for such a substitute it may be well to consider a moment what farmyard manure really is. It is, of course, the waste solid or liquid products of animals, mixed in most cases with a certain amount of litter used for bedding. Incidentally it may be stated that the litter is valuable for absorbing the liquid excreta, as without this the most valuable part of the waste pro-

ducts is frequently washed out and lost. The raw material from which these waste products are directly or indirectly derived is invariably vegetable matter, a cellulosic substance. The processes of digestion and assimilation of food in the animal system are promoted by ferments called enzymes and obviously if we can cause vegetable matter to undergo similar processes independent of the animal we are in a fair way to provide a substitute for farmyard manure. Not only so but the substitute will be better than the original.

In the case of the animal much of the most valuable constituents have been extracted to provide for the growth and energy of the animal. In the case of the substitute, however, the whole of the constituents will be present and, if the process is successful, in a readily assimilable form. Hence our aim must be to promote the decay of vegetable matter in such a manner that a product similar to farmyard manure is produced, but with all the most valuable constituents retained.

The value of plant tissue as a means of enriching soils with organic matter has long been recognised as shown by the fact that all up-to-date growers use every favourable opportunity of sowing catch-crops of a quick-growing nature and turning them in before the sowing of the next crop. This system of green manuring has been highly developed in certain districts and has resulted in the conversion of large tracts of sandy, barren soil into fertile areas. If it is worth while to grow crops to turn in for green manuring, it is surely worth while to conserve and turn into manure the large amount of waste vegetable matter which is available in such abundance on all plantations and estates.

Although it is known that the chief mineral and nitrogen requirements of a crop can be easily supplied by the application of chemical manures, experience shows that a plentiful supply of organic matter is indispensable for maintaining the fertility of soils. There is little doubt that the superiority of dung is due not so much to the mineral substance and nitrogen that it contains as to the organic, humus-forming material which forms its bulk. Plant nutrition is a much more complex matter than the mere provision or maintenance of the necessary elements, and it would appear that the chemical or bio-chemical changes which take place in the soil before food of plants is made available for absorption by the roots is largely dependent on its humus content.

Of the exact nature of humus little is known, and the term may be considered one of convenience rather than explanation. It is the black substance usually associated with a rich soil, and results from the decomposition of organic matter. Its influence as a fertiliser is mainly indirect, and may be considered conveniently under three headings, namely, physical, chemical and as a medium for soil bacteria.

As a physical agent the effect of humus is to improve the drainage and tilth of the soil. This increases to an enormous degree the area suitable for root action and may be illustrated by imagining the difference between an impervious lump of clay and the same intersected in every direction by innumerable channels through which roots, air and moisture may pass. Humus also helps the soil to retain moisture. For example experiments give the following results:—

100 lb of dry sand can hold 25 lb of water.
100 lb of dry clay can hold 50 lb of water.
100 lb of dry humus can hold 190 lb of water.

Humus is a non-conductor of heat, hence it fosters that equable soil temperature so desirable for steady growth.

Chemically humus acts probably as a catalytic agent; that is, it promotes chemical re-actions without apparently taking part in them. This type of action is quite common in chemical re-actions. For example the activity of some substances is increased many times when absorbed by charcoal and there can be little doubt that the same kind of re-action occurs in the soil. Besides this all decaying organic matter contains a considerable proportion of elements of direct, nutritive value as plant food. This cannot be disregarded, though it is proportionately less than in artificial manures.

Finally there is the question of soil bacteria importance in promoting certain chemical re-actions essential to soil fertility. These bacteria feed on the decaying vegetable matter which they help to break down and render available as food for plants. They can no more live in a soil without humus than human beings could live in a desert devoid of vegetation.

Having established the importance of humus as a fertilising agent it is necessary to inquire as to the natural supply of this substance in the soils with which we have to deal. The fibrous loams and parts which are the richest in humus are relatively small areas of the world's surface and even here deterioration starts from the moment cultivation begins and this is particularly rapid in the tropics where growth and decay are phenomenal. Every tropical planter can point to fields which once were fertile but which now are poor or abandoned and the amazing difference in the yield per unit or per area in highly cultivated plantations and those where cultivation is neglected is a striking example of the necessity of maintaining fertility. The centres of high fertility are gradually moving, whatever the crop, and the extensive use of artificials during the last fifty years has not checked this. That this loss of fertility can be avoided is shown by the manuring trials carried out at the Rothamsted Experimental Station on what is now the most famous wheat field in the world which produced its 75th crop in 1925. One crop in this field has received annually farmyard manure only, during whole period; other plots have been continuously manured with standard artificials and mixtures. A critical comparison of the records of these plots now reveals the fact that the only plot which shows no deterioration whatever is that which has received farmyard manure, thus it would appear that the only way to maintain fertility is by giving liberal dressings of humus-forming manure. The water-holding capacity of humus has already been noted, hence a soil with high humus content is an insurance against drought. Even a fertile soil without water becomes a desert as witness the changes from desert to highly productive areas in Egypt, Southern California and North-West India by the introduction of water. It is safe to say that the crops of the world are more dependent on water than nutrients in the soil and whilst rainfall is beyond human control we possess in humus the power to increase the water-holding capacity of any soil.

It is largely owing to a knowledge of these facts that the "Adco" process appeals to the thoughtful grower. It has been known to the public for a very short period, yet its fame is already world-wide. The Scientific discoveries on which it is based appeared unobtrusively in the scientific Press and notes regarding the process found their way into the agricultural journals. To-day manure is being produced by the Adco process in England, France, Spain, Canada, United States, West Indies, South and West Africa, New Zealand, Malaya, Australia, India, Ceylon, Japan, Rhodesia, and Mauritius while inquiries from all parts of the world increase daily. It has needed no advertising to achieve this success. It appealed immediately to all serious agriculturists for a very simple reason, it offered no novel, artificial fertiliser but simply farmyard manure the value of which every grower

understands. We call this manure synthetic farmyard manure or "Adco" manure because it is produced without the agency of animals.

Standard "Adco" is a fine powder which embodies late scientific discoverries. Its function is to create the ideal conditions which cause the useful bacteria to work and also to increase the amounts of plant nutrients in the finished manure. It is invaluable in the great grain growing districts where machinery is displacing the animal, and where large quantities of straw, maize stalks, &c., are available. It is ideal for the tropics where weeds and vegetation are plentiful and where fermentation is rapid. Dunging has never been sufficiently possible on the great plantations hitherto, but the "Adco" process now offers a simple and perfect means of accomplishing this. "Adco" manure is made by stacking and wetting any type of vegetable refuse layer by layer and mixing with it "Adco" powder until a pile about six feet high is completed. The stack should have a flat top so as to hold water, not shed it. After the stack has been built there is nothing to do but to keep it moist until it is well rotted and ready for use. The method of stacking the heaps depends to some extent on the type of material being treated and users of the process will soon gain experience as to the best methods. For the benefit of new users it may be helpful to describe more or less in detail the method of stacking a heap of material of say about five tons. It may at once be said that in the tropics a shallow trench about 2 feet deep is a decided advantage. For a heap of this weight about 7½ cwt. of standard of "Adco" would be required. Estimate roughly the division of the material into 6 lots and arrange the first lot on a square base with about 7 yards side. Water through a rose or any convenient form of sprayer and when well wetted sprinkle as evenly as possible 1-6th of the "Adco." Sprinkle with a little water just sufficient to clean the top of the layer. Spread another layer and continue the process until the whole of the material is in position and partly wetted seeing that the last layer of "Adco" is covered with a few inches of refuse and well wetted. In a few days the stack should heat to at least 80° F.; when another 1,000 gallons of water may be applied, and repeat this at intervals of about three days until the whole stack has received 4,000 gallons of water in all. The temperature will gradually rise until a maximum of 180° is reached but under certain conditions this may be as long as three or four weeks. Thorough trampling of the heap as it is built up is desirable and care should be taken that the top of the stack should be left as level as possible and not more than 6 or 8 feet high, the object being to facilitate the taking up and holding of the natural rainfall. The manure should be ready for use in from three to six months, the exact time depending on the nature of the material treated and the state of decomposition required of the finished product. A well made Adco heap can be cut out easily with an ordinary spade. It cannot be too much emphasised that the question of moisture is a controlling factor in the success of the process and uniformity of moisture throughout the heap is absolutely essential. A heap which is uniformly moist and well trampled ferments steadily with an even temperature curve, whereas a heap loosely packed with unmoistured portions is liable to violent fluctuations of temperature and besides seriously affecting the physical condition of the heap, it must not be forgotton that if the temperature rises too high valuable constituents may be lost through volatilisation.

Where large quantities of "Adco" manure are to be made the provision of water is sometimes a serious problem and it is obvious that "Adco" stacks should be made near a water supply. Every advantage should be taken of local conditions, however, to meet this problem. For example weeds, grass,

cuttings and sandy vegetable trimmings contain about 90 per cent. of water in their fresh state. If left exposed to wind and sunshine even for a short time this content is reduced to 15 per cent. and the necessity is entailed of applying the balance artificially.

Further, such fresh material is richer in nutrients than dried or withered material and it is thus of double advantage to use the fresh material.

In an exposed position the windward side of the heap will dry out quickly and check the fermentation, hence a sheltered spot is to be preferred or, as an alternative, a bank of earth can be thrown up or any other improvised protection can be arranged. In the rainy season in tropical or sub-tropical countries with from 5 to 10 inches of rainfall per month for three consecutive months no additional water is required after the stack is made.

Practically all the refuse from English agriculture and horticulture has been successfully treated and almost every waste known in tropical agriculture has been tested. Some yield better manures than others but all appear to be amenable to treatment. Some idea of the diversity of raw material will be gained from the following list of the more important examples which have proved suitable. Straw, including wheat, barley, oats, and rice; banana leaves, pineapple leaves, maize stalks, tea prunings, wild grasses, including lusenke of Uganda, goura of Brazil, sudd of the Nile, neld of Rhodesia, Lallang of Malaya and rushes of England, sugar cane trash, rice husks, water hyacinth, coffee waste, gayule, a rubber waste of Mexico, bracken, hop vines, wild sunflower, and garden refuse of every description.

The cost of making "Adco" manure is naturally a business concern of the would-be user of the process. Since local conditions overseas vary so greatly it is difficult to give reliable estimates for the cost of making in different countries and for the wide range of materials which are available. On the basis that 1 ton of dry material of a proportionately greater weight of moist material will produce 3 tons of finished product, it will take 2 tons of Standard "Adco" to produce 100 tons of well-rotted synthetic farmyard manure The present cost on the site may be taken at £14 10s. per ton thus it would cost to-day £29, plus labour costs on the spot to produce 100 tons of manure. Apart from actual cost, however, there is the advantage in "Adco" manure that it is more bulky than pen manure and 15 tons per acre is a good dressing, and has actually given better results than 20 tons of ordinary dung. Further on large estates the heaps can be spaced at convenient distances and thus save part of the cost of transport which would be entailed in moving dung purchased from an outside source.

Mr. C. A. Jones, Agronomist of the Ste. Madeleine Sugar Co., Ltd., stated that some years ago the Local Department of Agriculture tried an experiment to break down organic matter with the use of certain chemicals but that it was not entirely successful. This experiment, however, aroused a considerable amount of interest in the subject of increased output of pen manure on our estates and brought back to memory a letter received from Dr. Tempany, Director of Agriculture, Mauritius, in 1919, which was published in the *Agricultural News* describing a method used in Mauritius for producing pen manure in large quantities.

For the last few years the Ste. Madeleine Sugar Co. have been using a modification of the Mauritius method and by this means have increased their output of pen manure per head of stock very considerably. This modified method is quite simple and can be carried out in the ordinary pens found on sugar estates. The bedding instead of being thrown in the pens in its full length is passed through a cutter and the chopped up material is

spread evenly over the surface of the pen. Cattle then trample it down and their droppings supply the material required for breaking down the bedding. The pen manure produced per head of stock is in this way increased at least four-fold. The limiting factor being the amount of bedding that is available, as on most sugar estates the head of stock is ample.

The difficulty, however, on many estates is to get the manure out to all the fields. Many fields are situated at a distance from the railway or gravelled roads and for this reason it is often impossible to cart the manure from the pens to such fields in the wet season, the result being that in the past these fields have never been pen manured, consequently their fertility has been considerably lowered.

By the use of " Adco " it was hoped that fields so situated could be pen manured and it was with this object, mainly in view, that five trial heaps were laid down during the last year on the estates of the Ste. Madeleine Sugar Co.

Mr. Auton has given an account of the method used in setting up the heaps and Prof. Hardy has given the results of the chemical analyses of the resultant manure. At Mr. Auton's request, I have attempted to collect information as to the use of the manure, and taking the Union Hall heap as a typical example the following expenditure was incurred:—

Labour.—Cost of collecting trash in dry season setting, watering, turning and weighing of heaps ..	$45.00
Cost of " Adco."—6 cwt. at £14 10s. per ton ..	20.88
Total cost	$65 .88

The weight of the final manure made from 6 tons of trash and 6 cwts. of " Adco " was 21·6 tons. The cost therefore works out at slightly over $3·00 per ton of manure.

The cost of making Mauritius pen manure is probably less than this and it cannot be claimed that the " Adco " process is cheap. Indeed pen manure by whatever process it is made is expensive but there is no efficient substitute for it and it is an expenditure that has to be faced. At Ste. Madeleine we make something like 30,000 tons annually and we are anxious to increase this to 50,000 tons. The money that used to be expended in the purchase of artificial manure is now being used in making more and more pen manure. We are getting convinced that " Adco " will have its place in the future routine work of our estates as one means of adding to the humus content of our soils.

Mr. T. I. Potter asked: " Will Mr. Auton kindly inform us whether the " Adco " preparation can be applied to coconut husks with the object of converting these into synthetic manure for coconut estates ? I ask this question because a member, who was unable to be present to-day, and who owns a coconut plantation, is curious to know whether ' Adco ' can be used for this purpose on coconut estates, where a very large quantity of husks is allowed to decay under the trees. I am also anxious to know this myself."

The Chairman remarked that he did not believe that coconut husks would respond readily to treatment with " Adco " owing to the large percentage of tannin in the fibre, which acted a a preservative or resistant, and consequently delayed decomposition.

Mr. Auton observed that he had not experimented with coconut refuse, therefore he could not readily answer the question.

Mr. Jos. de Verteuil made some observation detailing his experiments at Valsayn in prefacing which he referred to the question asked by Mr. Potter.

Department of Agriculture,
Port-of-Spain, 8th February, 1927.

SYNTHETIC PEN MANURE PREPARED AT "ENDEAVOUR" ESTATE, CHAGUANAS, BY THE "ADCO" PROCESS.

Mr. Jos. de Verteuil, Agricultural Chemist of the Department of Agriculture, said that he had analysed Synthetic Pen Manure prepared at "Endeavour" Estate, Chaguanas, by the "Adco" Process with the following results:—

Dry grass, which had been cut two or three weeks previously, was used for making the heap.

Started 10th November, 1926.
Completed 16th November, 1926.
Put out in the field 1st to 4th February, 1927.
Heap 30 by 30 by 4½ feet—sunk to 19 inches.
130 lb of "Adco" was spread over each layer, one foot thick, and last layer covered with 3 to 4 inches dry grass.

The first layer was properly trampled and thoroughly wetted, but no further watering was necessary as there were good rains whilst the heap was being built up.

Cost.

Cutting grass from field (about 5 acres)	$9·85
Heading out grass	2·73
Carting 70 loads dry grass (¼ to ½ mile)	3·13
Building heap	3·28
Wetting heap after being built (3 times) ..	3·20
Cost of 520 lb "Adco" at $71·34 per ton ..	16·56
	$38·75
Average weight of a load dry grass 225–250 lb ..	7 to 8 tons.
61 loads manure obtained (7 loads weighed on an average 800 lb each)	21 tons.
Cost of manure per ton	$1·85

Analytical Results.

	Natural sample.		Dried at 100°C.
Water	77·38	....	—
*Organic and volatile matter .	15·76	....	69·67
†Mineral matter	6·86	....	30·33
	100·00	....	100·00
Containing	Per cent.		Per cent.
*Nitrogen	0·51	....	2·25
†Lime (CaO)	1·10	....	4·86
†Potassium oxide K^2O ..	0·26	....	1·15
†Phosphoric anhydrido P^2O^5	0·81	....	2·69

Professor F. Hardy, of the Imperial College of Tropical Agriculture, said that he had tested a sample of Synthetic Pen Manure, which was prepared at the St. Augustine Experiment Station, from Dry Cane Trash and he obtained the following results:—

Thirty-three tons of trash were weighed and treated with 2 tons of the "Adco" reagent.

The analytical results compared with air-dried cane trash and pen manure, also prepared at the Experimental Station, are as follows:—

	"Adco" Manure. Per cent.	Pen Manure. Per cent.	Cane trash. Per cent.
Moisture	74·03	71·65	15·42
Organic matter	17·38	16·86	75·57
Ash	9·20	12·50	9·01
Nitrogen	0·57	0·58	0·95
Nitrogen calculated on dry material ..	2·14	1·97	0·98

Proceedings of the Agricultural Society of Trinidad and Tobago, Vol. XXVII Part 2.

FIJI LIVESTOCK RECORD ASSOCIATION.

MINUTES OF MEETING OF BOARD OF DIRECTORS HELD ON THE 10TH APRIL, 1930.

Present: Senior Veterinary Officer; Messrs. Kiss, Barber and Craig. The Senior Veterinary Officer presided in the absence of the Superintendent of Agriculture.

1. The minutes of the previous meeting of the Board were read and confirmed.

2. Accounts, as under, were passed for payment:—

Leighton Ltd.—Rubber Stamps £0 9 9
Government Printer—Rules 1 7 6

3. The Chairman pointed out that under the Rules of the Association animals registered on account of each owner were required to be numbered consecutively either by fire-brand or by tattoo. He stated that many owners did not possess the facilities for the numbering of animals and suggested that the Association purchase either a set of brand numbers or a tattooing instrument. After discussion the Board directed that a tattooing instrument be purchased from the Association's funds.

4. The Chairman stated that a number of applications for registration had been received and that the animals would be inspected as soon as possible and the Herd Book opened.

COPRA PRICES.

LETTER TO DIRECTOR, IMPERIAL INSTITUTE, LONDON.

Sir, 31st December, 1929.

I have the honour to request that you would be good enough to forward to me, periodically, records of comparative prices of the different grades of copra marketed in London and Hull, and if possible, those ruling in Hamburg, Rotterdam, Marseilles and Genoa.

2. The copra industry of Fiji is feeling the depression of prices somewhat keenly. I feel that very much lies in the direction of better organisation of the industry somewhat on the lines of the rationalisation methods talked of, and doubtless practiced in Europe during the recent two years or so.

3. The quality of South Sea copra leaves much to be desired, and the matter of suggesting certain improvements directed to the production of a better grade of copra is receiving my attention. I shall be grateful at a

later date for the co-operation of the Imperial Institute on the lines afforded Zanzibar during the tenure of my office there. The copy of the report on the four samples of Zanzibar copra examined at the Institute, and submitted to Brokers for their information, handed to me by Mr. Brown, has been of considerable use to me personally, and no doubt was welcomed by the Department in Zanzibar, as it gives more definite information regarding the relative prices of the grades of copra submitted than was hitherto available.

4. I shall be grateful for the expression of an opinion as to the main reasons for the continued fall in the market value of copra; whether prices have reached a stable level or whether they are likely to continue to fluctuate considerably in the near future. My own view is that the recent amalgamations of the largest consuming companies have cut down competition for vegetable oils to a great extent and thus contributed to a reduction in the market price of copra, as well as of other oil-bearing materials.

5. I realise that this is only one factor, but it nevertheless seems to me to be an important one, and it is necessary for the business of production to be so organised as to keep down production and marketing costs.

6. You might care to invoke the assistance of the Empire Marketing Board in this matter, which is of great importance to the Colony of Fiji.

I have, &c.,
A. C. BARNES,
Superintendent of Agriculture.

REPLY FROM DIRECTOR, IMPERIAL INSTITUTE, LONDON.

Imperial Institute,
London, S.W.7.
17th April, 1930.

Sir,

With reference to your letter No. 1405/29 of the 31st December last on the subject of copra prices, I shall be glad to send you periodically a list of the comparative prices of the different grades of copra marketed in Europe.

A table is enclosed, taken from the Copra Market Report issued by Messrs. L. M. Fischel & Co., giving the c.i.f. quotations for different grades of copra at the principal European ports on the 15th January, 19th February and 5th March, 1930. The London, Rotterdam and Hamburg c.i.f. quotations are identical, but the Marseilles values differ slightly and are given separately.

A copy of Messrs. Fischel & Co.'s report dated the 26th March is also enclosed. This includes notes on the market position, the c.i.f. quotations referred to above, and the principal daily spot prices fixed by the London Copra Association.

You do not indicate how frequently you would like to have such reports but it is proposed to send you a copy of Messrs. Fischel's report at the end of each month. I shall be glad to learn whether the information given in the report and the proposed interval of despatch will meet your requirements.

The Imperial Institute will be glad to assist in any possible way to promote the improvement of the copra produced in Fiji and to furnish reports, on the lines of that previously supplied to Zanzibar, on any samples which you may forward for examination.

With reference to your inquiry regarding the market value of copra, it is generally held in the trade that the following factors have contributed to the fall in price.

A large increase in the shipments of copra from the principal producing countries (exclusive of the South Seas and African supplies) occurred in 1928, during which year the total shipments from these sources were 30 per cent. (*i.e.*, about 200,000 tons) higher than the average for the three preceding years. The figures for 1929 indicate that this increase has been maintained.

During the same period there was also a considerable increase in the shipments of a number of other important oils and oilseeds including whale oil, which is now being largely used in the edible oil trade. Statistics giving the shipments of copra, palm kernels, groundnuts, soya beans, olive oil and whale oil during the last three years are enclosed. This increased production has tended to depress the prices of all oils and oilseeds, and the difficulty has been accentuated recently by a marked decline in the demand for feeding cake and meal. The latter is attributed chiefly to the excellent grain crops obtained last year in most European countries as a result of which large quantities of coarse grain have become available for feeding purposes.

It is also held that well-organised buying by the principal users of copra and dependent selling by producers have helped to lower the price. In this connection it is alleged that the formation of the Margarine Union has had an important effect as it is stated that the Union has established a single buying agency, thereby eliminating competition between its constituent firms, and is able by virtue of the large scale of its market operations to influence the price of copra and other oilseeds.

At present it is difficult to make any forecast as to the future position, especially in view of the general economic situation and the fall which has occurred in almost all commodity values. The whole question is however being kept in view here and, in this connection, your suggestion that the Empire Marketing Board might be consulted will be borne in mind.

The trade reviews on the Oil and Oilseed markets during 1929 have just been issued by Messrs. Faure Blattman & Co. and Messrs. Frank Fehr & Co. and copies of their remarks on copra and coconut oil are attached for your information.

HAROLD BROWN,
for Director (Lt.-Gen. Sir William Furse).

COPRA.

NOMINAL QUOTATIONS AT EUROPEAN PORTS, c.i.f. d/w, USUAL TERMS.

	15th January, 1930 January/February shipment.						19th February, 1930 February/March shipment.						5th March, 1930 March/April shipment.					
	Ports.*			Marseilles.			Ports.*			Marseilles.			Ports.*			Marseilles.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Malabar .. G.W.S.	24	7	6	24	7	6	23	12	6	23	12	6	22	15	0	22	15	0
Ceylon .. F.M.S.	24	2	6	24	2	6	23	7	6	23	7	6	22	7	6	22	7	6
Singapore .. F.M.S.	22	15	0	22	15	0	22	7	6	22	7	6	21	5	0	21	5	0
Straits .. F.M.	22	0	0	22	0	0	21	10	0	21	7	6	20	7	6	20	5	0
East Africa .. F.M.S.	21	15	0	21	15	0	21	10	0	21	7	6	20	7	6	20	5	0
Manila .. F.M.	21	10	0	21	10	0	21	0	0	21	0	0	19	12	6	19	12	6
Cebu .. .. F.M.S.	21	17	6	21	12	6	21	10	0	21	5	0	20	2	6	20	2	6
Macassar, &c. F.M.	21	10	0	21	10	0	21	0	0	21	0	0	20	0	0	19	17	6
Plantation Rabaul South Sea	21	17	6	21	12	6	21	12	6	21	7	6	20	7	6	19	17	6
South Sea .. F.M.S.	21	15	0	21	10	0	21	10	0	21	5	0	20	5	0	19	15	0

* London Rotterdam, Hamburg.

COPRA MARKET REPORT—26TH MARCH, 1930.

L. M. FISCHEL & Co., LTD., 36 AND 37, MINCING LANE, LONDON, E.C. 3.

We have to report an irregular market during the past week. At the opening a firm tone prevailed owing to a good demand from dealers for speculative grades, together with a better inquiry from consumers, and prices advanced 7/6 to 12/6 per ton. At the higher levels, however, buyers became more reserved and part of this improvement was soon lost, since when business has taken place at prices which have fluctuated within narrow limits, shippers generally have refrained from offering to any extent and at the close the tone is quiet but steady with quotations unchanged to 10/- higher than last week.

The Marseilles market opened firm and up to £20 10s. was reported paid for Kiln-dried South Sea Afloat, and £20 7s. 6d. for March/April shipment, with other grades on a parity. Following this, prices gave way about 5/- per ton and at the lower level a fair business is reported in most grades, with afloat parcels commanding a premium of 2/6 to 5/- per ton, according to the steamer's position. At the close nearest values may be given as £20 2s. 6d. for Kiln-dried South Sea, and £20 5s. for Mixed Dutch East Indies, March/April shipment.

There has been a moderate inquiry from Northern European ports although the business reported is small.

Nominal Quotations for April Shipment c.i.f. d/w Usual Terms.

	1930.		1929.	
	c.i.f. usual Ports.	c.i.f. Marseilles.	c.i.f. usual Ports.	c.i.f. Marseilles.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
Malabar .. .. .. G.W.S.	23 0 0	23 0 0	24 10 0	24 10 0
Ceylon .. .. .. F.M.S.	22 12 6	22 12 6	24 5 0	24 5 0
Singapore .. .. .. F.M.S.	21 10 0	21 10 0	23 7 6	23 7 6
Straits .. .. .. F.M.	20 10 0	20 10 0	22 15 0	22 10 0
East African .. .. .. F.M.S.	20 7 6	20 10 0	22 10 0	22 10 0
Manila .. .. .. F.M.	20 0 0	20 0 0	22 7 6	22 7 6
Cebu .. .. .. F.M.S.	20 10 0	20 7 6	22 15 0	22 10 0
Macassar, &c. .. .. F.M.	20 5 0	20 5 0	22 5 0	22 5 0
Plantation Rabaul South Sea	20 12 6	20 10 0	22 15 0	22 10 0
South Sea .. .. .. F.M.S.	20 12 6	20 7 6	22 12 6	22 7 6

Principal Daily Spot Prices fixed by the London Copra Association, 21st March:—

London—basis bags—F.M.S. Ceylon, £22 7s. 6d.; West Indian, £21 12s. 6d.; F.M.S. Java, £21 10s.; F.M.S. Dutch East Indies, £21 7s. 6d.; Mixed Dutch East Indies, £20 7s. 6d.; F.M.S. Straits, £21 7s. 6d.; F.M. Straits, £20 10s.; F.M.S. Mozambique, £20 15s.; F.M.S. Philippine, £20 12s. 6d.; F.M. Philippine, £20 5s.; H.A.D, Plantation Rabaul, £20 17s. 6d.; F.M.S. Plantation Rabaul, £20 17s. 6d.; Plantation South Sea, £20 15s.; F.M.S. Samoa, £20 15s.: F.M.S. South Sea, £20 12s. 6d.

Liverpool, Antwerp, Germany, Holland same as London; Hull, 5/- extra.

STATISTICS OF THE TOTAL SHIPMENTS OF SOME OF THE PRINCIPAL OILSEEDS AND OF THE WORLD'S PRODUCTION OF OLIVE AND WHALE OIL, DURING 1927, 1928 AND 1929.

COPRA AND COCONUT OIL.

	1927	1928	1929	
Copra.	*tons.*	*tons.*	*tons.*	
Total shipments from the principal producing countries (exclusive of South Seas and African supplies).	676,481 .. 680,341	866,317 .. 875,224	900,908 .. 859,580	Review of the Oil and Fat Markets, 1929, by Faure Blattman & Co. Particulars of shipments of Copra by L. M. Fischel & Co.
Coconut Oil.				
Exports from principal producing countries.	199,000 ..	221,000 ..	(*a*)	Official figures.

(*a*) The official figures so far available indicate that the total in 1929 should not be less than in 1928.

PALM KERNELS.

Palm Kernals.	1928 *tons.*	1929 *tons.*	
Total imports into principal European countries.	491,964	479,856	Faure Blattman & Co.

GROUNDNUTS.

Shipments from	1927 *tons.*	1928 *tons.*	1929 *tons.*	
India—				
Groundnuts	474,882 ..	748,603 ..	816,379	Official figures.
Groundnut oil (gallons)	55,886 ..	352,341 ..	269,867	Do.
China—				
Unshelled	54,379 ..	55,522 ..	*	Do.
Shelled	91,724 ..	46,261 ..	*	Do.
Senegal	399,202 ..	406,986 ..	380,313†	Do.
Gambia	65,107 ..	74,442 ..	49,751‡	Do.
Nigeria	90,773 ..	103,161 ..	94,330‡	Do.

* Information not yet available. † January–December 15th. ‡ January–September.

The official figures for the total production of unshelled groundnuts in India are 2,046,000 tons in 1926–27 and 2,657,000 tons in 1927–28.

The following figures of the total imports of groundnuts into the principal consuming countries are given by Messrs. Faure Blattman & Co.

1927 *tons.*	1928 *tons.*	1929 *tons.*
1,249,378 ..	1,605,926 ..	1,747,834

SOYA BEANS AND OIL.

Shipments from	1926–27* *tons.*	1927–28* *tons.*	1928–29* *tons.*	1929† *tons.*	
Manchuria—					
Soya beans	1,621,697 ..	2,040,982 ..	2,897,200 ..	573,400	Faure Blattman & Co.
Soya oil ..	167,098 ..	89,235 ..	98,718 ..	21,457	Do.

* 1st November to 31st October. † November and December.

OLIVE OIL.

	1927 *tons.*	1928 *tons.*	1929 *tons.*	
World's production ..	965,000 ..	718,000 ..	1,007,000	Review of the Oilseed, Oil and Oil Cake Market by Frank Fehr & Co.
World's production ..	1,079,021 ..	627,648 ..	1,003,347	Faure Blattman & Co.

WHALE OIL.

	1927 *barrels.*	1928 *barrels.*	1929 *barrels.*	
World's production ..	1,220,415 ..	1,356,308 ..	1,861,877	Frank Fehr & Co.
	tons.	*tons.*	*tons.*	
Converted at rate of 6 barrels.	203,400 ..	226,050 ..	310,313	

EXTRACT FROM "REVIEW OF THE OIL AND FAT MARKETS, 1929."

(Published by Messrs. Faure Blattman & Co.).

COPRA AND COCONUT OIL.

Our forecast that 1929 would be a year of large copra supplies, and that the bulk of the surplus over previous years would be taken care of by the U.S.A. has proved correct. The total shipments for the year amounted to 900,908 tons against 866,317 tons last year, and the total copra imports into the U.S.A. for the year amounted to 253,543 tons against 221,172 tons in 1928. The total imports into the principal consuming countries were 1,115,909 tons during 1929 against 974,946 tons in the previous year. Generally speaking, the copra shipments were heavy during the first half of the year, but showed a considerable falling off towards the latter part, the most noticeable drop being in the exports from the Philippines.

The imports of copra and coconut oil into the U.S.A. for 1929 show a considerable increase over the previous year, the total quantity of copra calculated as oil and coconut oil combined imported during 1929 amounted to 349,060 tons in 1929 against 273,536 tons in 1928. Undoubtedly the U.S.A. imported in excess of their requirements in anticipation of a tariff being imposed which is borne out by the increase in stocks, which, for copra as oil and coconut oil combined, amounted to 89,307 tons on the 31st December, 1929, against 65,034 tons on the 31st December,

1928. The excess quantity was mainly bought at the beginning of the year when America sent over large orders for Straits copra. Early in the Summer, America ceased to compete for supplies of Straits copra, but entered the market again in December, when further heavy purchases were made.

The Philippine copra shipments show a considerable falling-off being only 167,145 tons against 218,921 tons in 1928, but this is largely accounted for by an increased quantity of Philippine copra being shipped to the U.S.A. in the form of coconut oil. The shipments of coconut oil from the Philippines to the U.S.A. amounted to 186,816 tons in 1929, against 136,344 tons in 1928.

On the whole, the tendency of the market has been downward, the lowest price being reached in June, when sun-dried Straits and sun-dried D.E.I. was actually sold at £20 5s. nett. When the market had reached this level, however, the U.S.A. once again bought heavily, with the result that a sharp reaction set in, until £23 12s. 6d. was reached in September. The market then became sluggish and with small fluctuations gradually receded to £22 10s., which was the value at the end of the year.

During the first half of the year copra was cheap when compared to other oilseeds but during the second half of the year the position was reversed, and copra was not affected by the general drop which took place.

The reports from the Dutch East Indies, the Philippines, Straits and Ceylon, all seem to indicate the probability of small supplies during the next few months, but there is no reason why there should not be an improvement later in the year.

There seems to be again a tendency to increase the production of coconut oil in the copra-growing countries, as is shown by the increase in the shipments from the Philippines, also from the D.E.I. and from Ceylon.

EXTRACT FROM "REVIEW OF THE OILSEED, OIL AND OIL CAKE MARKETS FOR 1929."

(Published by Messrs. Frank Fehr & Co.).

COPRA.

Production of copra has again increased during the year under review.

Total shipments, including those of "Other Dutch East Indies," were 918,340 tons for 1929, compared with 905,398 tons in 1928.

Shipments to the United Kingdom rose to 90,299 tons, compared with 61,901 tons for 1928.

German imports were also larger at 240,696 tons for 1929, against 197,587 tons in 1928.

French imports, which were 180,960 tons in 1928, also show an improvement, being 188,370 tons for 1929.

Holland also shows a slightly higher figure at 140,272 tons, against 137,078 tons.

Imports into the U.S.A. during 1929 stood at 254,880 tons, compared with 223,652 tons for the previous year. In connection with this it is also interesting to note that apart from larger imports of copra, the quantity of coconut oil taken by the U.S.A. during 1929 was 183,900 tons, compared with 129,750 tons in 1928.

Examining the export figures, we observe a decline in the shipments of Manila copra, being 178,018 tons for 1929, against 201,000 tons for 1928. This difference, however, is well replaced by the larger shipments of coconut oil.

On the other hand shipments from the Dutch East Indies were more liberal, being 452,757 tons, compared with 436,493 tons for 1928.

The same refers to exports from the Straits Settlements, which rose to 186,112 tons, against 173,555 tons; while Ceylon shipments were also higher at 101,453 tons, against 94,250 tons.

There was a slight increase in the shipments of Ceylon and Java coconut oil during 1929. Ceylon exported 41,523 tons compared with 36,056 tons for the previous year, and Java 34,433 tons, against 33,537 tons.

The average price of F.M.S. Singapore copra c.i.f. London, during 1929 was £23 1s. 3d., compared with £26 7s. 6d. for 1928 and £27 7s. 6d. in 1927. The average price for 1929 was the lowest for recent years.

We started the year at £24 7s. 6d. in January, which price with minor fluctuations was maintained during February. In March we fell to £23 5s. and by June we were down to £21. In July prices improved to £23 6s. 3d. This higher level of prices was maintained during August and September, the average during the latter month being £24 1s. 3d. As shipments became more liberal and demand for cake decreased, the copra market followed the decline in the markets of other oilseeds and at the end of the year we saw the price down again to £22 12s. 6d.

It will be observed, however, that the decline in the price of copra since the turn of the year has been in no way as drastic as that of other oilseeds. The lowest price we have seen for copra was £20 17s. 6d. on the 7th March, 1930. During the same period the price of palm kernels fell to £14 5s. for afloat parcels, and that of Coromandel groundnuts to £15. The explanation of this can be found in the fact that at a low level of prices for cakes, the crushers naturally give preference to oilseeds containing the highest percentage of oil, or to copra "par excellence."

COCONUT OIL.

Manila.—During 1927 and 1928 the market for Manila coconut oil in America fluctuated between 8¼ and 8¾ cents per lb, c.i.f. New York, but in 1929 there was a wider movement. In January the average price in New York was 8⅛ cents per lb. In August it fell to 6¾ cents, and closed in December at 7 cents per lb. It is interesting to observe the large increase in the imports of Manila coconut oil into the U.S.A., which rose from 129,750 tons for 1928 to the enormous figure of 183,900 tons during 1929.

Ceylon.—There is a further increase in the shipments of Ceylon coconut oil, which were 41,523 tons during 1929, against 36,056 tons in 1928 and 30,255 tons for 1927. In our last report we mentioned the gradual decline in prices of £4 to £5 per ton. A similar decline took place during 1929, so that compared with values ruling during 1927, the price of Ceylon coconut oil shows a fall of, approximately, £10 per ton. The United Kingdom and Italy were again the principal buyers of this commodity.

Java.—Shipments from Java show a small increase, being 34,433 tons in 1929, compared with 33,575 tons in 1928.

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